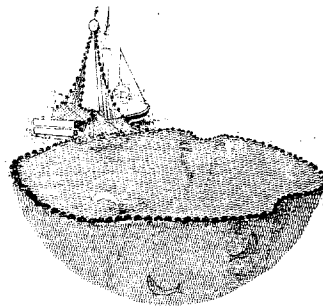
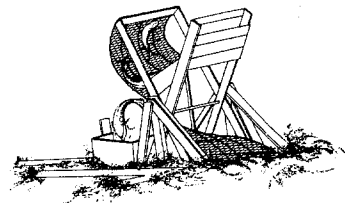
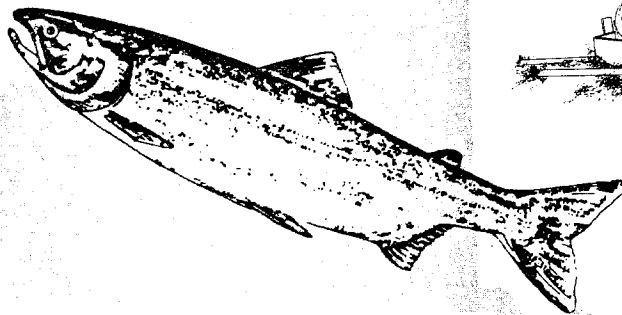
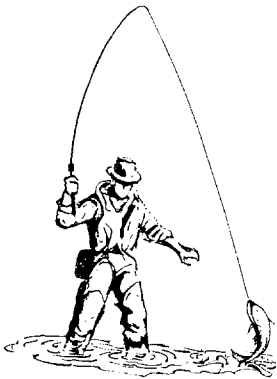
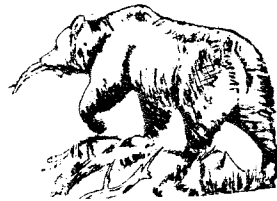


RUN TIMING AND ABUNDANCE OF ADULT SALMON IN THE TULUKSAK RIVER, YUKON DELTA NATIONAL WILDLIFE REFUGE, ALASKA, 1991

Alaska Fisheries Progress Report Number 95-1



February 1995

Region 7

U.S. Fish and Wildlife Service • Department of the Interior

Run Timing and Abundance of Adult Salmon in the
Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1991

Progress Report

Ken C. Harper

U.S. Fish and Wildlife Service
Kenai Fishery Resource Office
P.O. Box 1670
Kenai, Alaska 99611

April 1995

Disclaimer

The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

The correct citation for this report is:

Harper, K.C. 1995. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1991. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Progress Report Number 95-1, Kenai, Alaska.

Abstract

A resistance board weir was used to collect run timing, abundance, and biological data from salmon in the Tuluksak River June 12-September 18, 1991. A total of 7,675 chum *Oncorhynchus keta*, 697 chinook *O. tshawytscha*, 34 sockeye *O. nerka*, 392 pink *O. gorbuscha*, and 4,651 coho *O. kisutch* salmon were counted through the weir. Peak weekly passages for salmon occurred: July 7-13, chum and chinook; July 14-20 sockeye and pink; and coho, September 1-7.

Thirty-five Dolly Varden *Salvelinus malma*, 163 whitefish *Coregonus* and *Prosopium* spp., 28 Arctic grayling *Thymallus arcticus*, and 17 northern pike *Esox lucius* were also counted through the weir. Whitefish moved primarily in September while other resident species moved in July. Only larger resident species are represented because of picket spacing.

Salmon sex ratios varied by week for all species. Female chinook salmon composed only 28.8% of the passage. Gill net marks were observed on 5% of the chum, 10% of the chinook, <2% of the pink, 6% of the sockeye and 9% of the coho salmon sampled at the weir. Net marks were found on 5% of the female chinook salmon sampled at the weir.

The optimal time to perform aerial surveys for chinook salmon on the Tuluksak River was the last week of July. Over 90% of the chinook salmon run had passed upstream by that date and the number of carcasses was minimal. An aerial survey for chum salmon during this week would only have 50 to 70% of the run available and a substantial portion of the fish would have died. Aerial surveys for chum salmon should be flown more than once to determine total abundance.

Swimming speeds between the test fishery at Bethel and the Tuluksak River weir and stream-life above the weir were estimated by using the difference between the 50% cumulative passage dates at each location. Chinook salmon had a shorter immigration time into the river and were estimated to swim slower than chum salmon, making them more vulnerable to harvest.

Table of Contents

	<u>Page</u>
Abstract	i
List of Tables	iii
List of Figures	iii
List of Appendices	iv
Introduction	1
Study Area	4
Methods	4
Weir Operation	4
Biological Data	6
Migration Timing	8
Results	9
Weir Operation	9
Biological Data	9
Chum salmon	9
Chinook salmon	15
Pink salmon	18
Sockeye salmon	18
Coho salmon	18
Migration Timing	20
Aerial Survey	20
Discussion	24
Biological Data	24
Chum salmon	24
Chinook salmon	24
Pink salmon	25
Sockeye salmon	25
Coho salmon	25
Migration Timing	26
Aerial Survey	27
Recommendations	27
Acknowledgements	28
References	29
Appendices	32

List of Tables

<u>Table</u>	<u>Page</u>
1. Age, length (mid-eye to fork length) and weight composition of chum salmon sampled at the Tuluksak River weir, Alaska, 1991.....	15
2. Age, length (mid-eye to fork length) and weight composition of chinook salmon sampled at the Tuluksak River weir, Alaska, 1991.....	17
3. Age, length (mid-eye to fork length) and weight composition of sockeye salmon sampled at the Tuluksak River weir, Alaska, 1991.....	19
4. Age, length (mid-eye to fork length) and weight composition of coho salmon sampled at the Tuluksak River weir, Alaska, 1991.....	20

List of Figures

<u>Figure</u>	<u>Page</u>
1. Lower Kuskokwim River tributaries on the Yukon Delta National Wildlife Refuge, Alaska.....	3
2. Fish weir location on the Tuluksak River, Alaska, 1991.....	5
3. Salmon counted through the Tuluksak River weir, Alaska, June 12-September 18, 1991.....	10
4. Resident fish counted through the Tuluksak River weir, Alaska, June 12-September 18, 1991.....	12
5. Comparison of cumulative salmon upstream passage and fish carcasses passed downstream, Tuluksak River weir, Alaska, 1991.....	13
6. Weekly sex composition (expressed in % females) of salmon sampled at the Tuluksak River weir, Alaska, 1991...	16

	<u>Page</u>
7. Cumulative daily passage at the Tuluksak River weir and at the Bethel test fishery, Alaska, 1991.....	21
8. Comparison of run timing for chum salmon in the Tuluksak River and catch per unit of effort (CPUE) in the lower Kuskokwim River commercial fishery, Alaska. CPUE data is plotted 11 days after the actual date.....	23

List of Appendices

<u>Appendix</u>	<u>Page</u>
1. Aerial index surveys for chinook and chum salmon in the Tuluksak River, Alaska, 1960-1991.....	32
2. Water elevation and temperatures in the Tuluksak River, Alaska, 1991.....	33
3. Total daily weir counts of anadromous, anadromous gill net marked and resident fish species, Tuluksak River, Alaska, 1991.....	34
4. Daily counts and cumulative proportion of run for chinook, chum, pink, coho and sockeye salmon in the Tuluksak River, Alaska, 1991.....	37
5. Fish carcasses counted on the upstream side of the Tuluksak River weir, Alaska, 1991.....	40
6. Estimated age and sex composition of weekly chum salmon passage from the Tuluksak River, Alaska, 1991, and test for age composition difference between sexes.....	42
7. Estimated age and sex composition of weekly chinook salmon passage from the Tuluksak River, Alaska, 1991, and test for age composition difference between sexes in the escapement.....	45
8. Estimated age and sex composition of weekly sockeye salmon passage from the Tuluksak River, Alaska, 1991.....	47
9. Estimated age and sex composition of weekly coho salmon passage from the Tuluksak River, Alaska, 1991, and test for age composition difference between sexes.....	48

Introduction

The Tuluksak River is one of several lower Kuskokwim River tributaries on the Yukon Delta National Wildlife Refuge (Refuge). Located at river kilometer (rkm) 218 on the Kuskokwim River, the Tuluksak River provides important spawning and rearing habitat for chinook *Oncorhynchus tshawytscha*, chum *O. keta*, sockeye *O. nerka*, pink *O. gorbuscha* and coho *O. kisutch* salmon (Alt 1977; U.S. Fish and Wildlife Service 1992). Salmon escapements provide food for brown bears *Ursus arctos* and other carnivores, raptors, and scavengers. In addition, resident fish and salmon fry rely heavily on the nutrient base provided by salmon carcasses (U.S. Fish and Wildlife Service 1992). Salmon from these lower Kuskokwim River tributaries also contribute to one of the largest and most intense subsistence salmon fisheries in Alaska, and pass through a commercial fishery district between the mouth and the Tuluksak River (Francisco et al. 1992; U.S. Fish and Wildlife Service 1988, 1992).

Managing the Kuskokwim River for sustainable harvests requires that individual tributaries receive adequate escapements. Harvest management is complicated by the mixed stock nature of the lower Kuskokwim River fishery. Harvest level guidelines for the current year are determined from test and commercial fishery catch data indices at Bethel and from lower river commercial fishery harvests. Managers try to distribute catch through time to avoid over harvesting species and stocks returning to one of the 11 major and numerous minor tributaries of the Kuskokwim River. Distribution of the catch is necessary because each stock may have a characteristic migratory timing (Mundy 1982). Stocks or species returning in low numbers may be over harvested incidentally during extended harvesting of abundant stocks. Data are lacking on many of these individual stocks in the Kuskokwim River drainage and are needed for better management.

Most of the chinook salmon harvest occurs in the lower Kuskokwim River. Harvest in the lower Kuskokwim River increased from 1985 to 1991 and ranged from 35,443 to 68,018 in the subsistence fishery and from 18,171 to 51,656 in the commercial fishery (Francisco et al. 1992). A conservation concern developed in the mid 1980's when escapements were low. Low escapements were further compounded by the low number of female chinook salmon in the escapement.

The Alaska Department of Fish and Game (Department) reduced the average yearly commercial harvest of females from 42.8% to 32.1% by reducing gill net mesh size from >20.3 cm to ≤15.2 cm (Francisco et al. 1994). The number of gillnet marked females at escapement projects increased after the mesh size change (Doug Molyneaux, Alaska Department of Fish and Game, personal communication). Escapements continued to decline prompting the Department to eliminate the directed commercial harvest of chinook salmon. Harvest of surplus fish was reserved for the priority subsistence fishery. Elimination of the directed commercial harvest and restriction of the mesh size during the chum salmon fishery helped to rebuild stocks to escapement objective levels. Chinook salmon

currently harvested in the commercial fishery are those taken incidentally during the directed chum salmon openings.

Commercial harvests of chum salmon have exceeded 200,000 every year since 1975, reached a record of 1,327,006 in 1988, and declined to 345,299 fish in 1991 (Francisco et al. 1992). Coho salmon commercial harvests have increased from less than 50,000 fish in the early 1960's to over 450,000 fish during most years since 1985. Subsistence users from villages in the lower Kuskokwim River harvested an estimated 41,842 coho salmon and 53,783 chum salmon in 1991. From 1974 to 1990, even year commercial harvests of pink salmon have ranged from 16,569 to 85,978.

Chum and chinook salmon abundances in the Tuluksak and other tributary rivers on the Refuge have been estimated on an opportunistic basis by the Department using aerial index surveys (Schneiderhan 1983, 1988; Francisco et al. 1992). These aerial index surveys are usually conducted after the salmon are on the spawning grounds. Weather delays and poor visibility make some aerial index surveys of questionable value. Even during optimal conditions these counts underestimate escapement. Escapement data including age, sex and size composition cannot be collected with aerial index surveys. Aerial index surveys are usually conducted too late to make management decisions that allow more fish to reach the spawning grounds and meet escapement objectives. The Refuge has supported these aerial index surveys in recent years with aircraft and pilots because it represents the only data for several tributaries. Information to determine optimal aerial index survey timing for refuge rivers has not been collected.

Chinook and chum salmon aerial index counts on the Tuluksak River have been below 50% of the aerial index objective for most years (Appendix 1). Coho salmon escapement objectives have not been set for rivers on the Refuge because limited escapement data have been collected.

The Department has gathered limited fishery data on lower Kuskokwim River drainages on the Refuge. In 1978, a sonar project was tried on the Kwethluk River but was dropped after high debris loads gave false readings (Schneiderhan 1979). The Department now operates two salmon escapement projects, the Aniak River sonar and Kogruklu River weir. Both projects are located above the commercial fishery at about 378 and 781 rkm from the mouth of the Kuskokwim River (Figure 1). Spawning escapement counts from the Aniak River sonar, Kogruklu River weir, catches in the Bethel test fishery, and lower Kuskokwim River commercial fishery are used to make management decisions. These decisions effect escapements to all tributaries including those on the Refuge.

The Alaska National Interest Lands Conservation Act mandates that, within the Refuge, salmon populations and their habitats be conserved. Refuge mandates, however, may not be met without conservative management

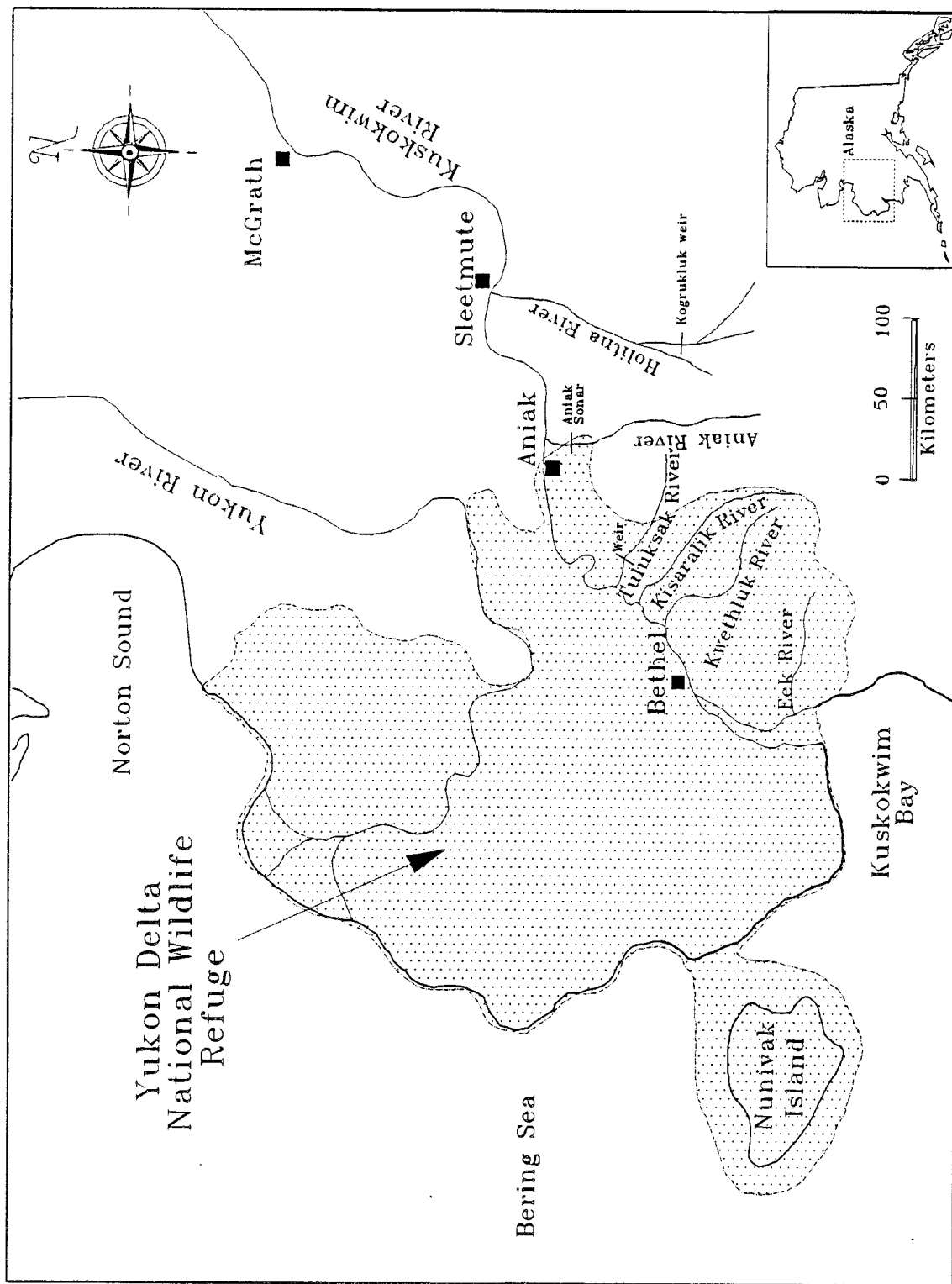


FIGURE 1.—Lower Kuskokwim River tributaries on the Yukon Delta National Wildlife Refuge, Alaska.

practices since reliable data on lower tributary fish stocks are missing. Salmon escapement studies for lower Kuskokwim River tributaries on the Refuge are ranked as priority projects in the Refuge Fishery Management Plan by the U.S. Fish and Wildlife Service (Service) and the Department (U.S. Fish and Wildlife Service 1992).

As the human population in regional villages expands, the need for accurate escapement data from the lower Kuskokwim River tributaries on the Refuge will increase. In 1991, a multi-year study was started by the Service to: (1) estimate daily salmon escapements in the Tuluksak River; (2) quantify the salmon age, sex, and length composition; (3) estimate migration time between the test or commercial fishery and the weir; (4) monitor gillnet marks on salmon; (5) estimate optimal timing to gather aerial index survey data; and (6) count other species passing through the weir.

Study Area

The Tuluksak River is located in the lower Kuskokwim River drainage (Figures 1, 2). The region has a subarctic climate characterized by extreme temperatures. Summer temperatures average a high of 15°C and average winter lows are near -12°C (Alt 1977). Average yearly precipitation is about 50 cm with the majority falling between June and October. River break-up occurs in early May and freeze-up occurs in late November.

The Tuluksak River starts in the Kilbuck Mountains, flows northwest approximately 137 km, and drains an area of about 2,098 km². The Fog River is the only major tributary to the Tuluksak River, and enters in the lower section. The Tuluksak River is a slow moving, meandering stream over most of its length, cutting through several tundra areas in its lower section (Alt 1977). Gravel bottoms and cut banks with overhanging vegetation predominate in the upper sections of the river. Water clarity in the upper section is 1-2 m during low water. The lower section is characterized by deep channels that are mud lined and the water is turbid.

Gold dredging operations near the mining camp of Nyac (Figure 2) since the early 1900's has extensively changed the upper drainage above the refuge boundary (Crayton 1990; Francisco and Sundberg 1983). Dredging activity is now confined to Bear Creek, a tributary to the Tuluksak River above the refuge boundary, but may be expanded.

Methods

Weir Operation

A resistance board weir with picket spacing of 3.5 cm spanning 48 meters of river (Tobin 1994) was installed at rkm 76 (N 60°, 59', 160°,

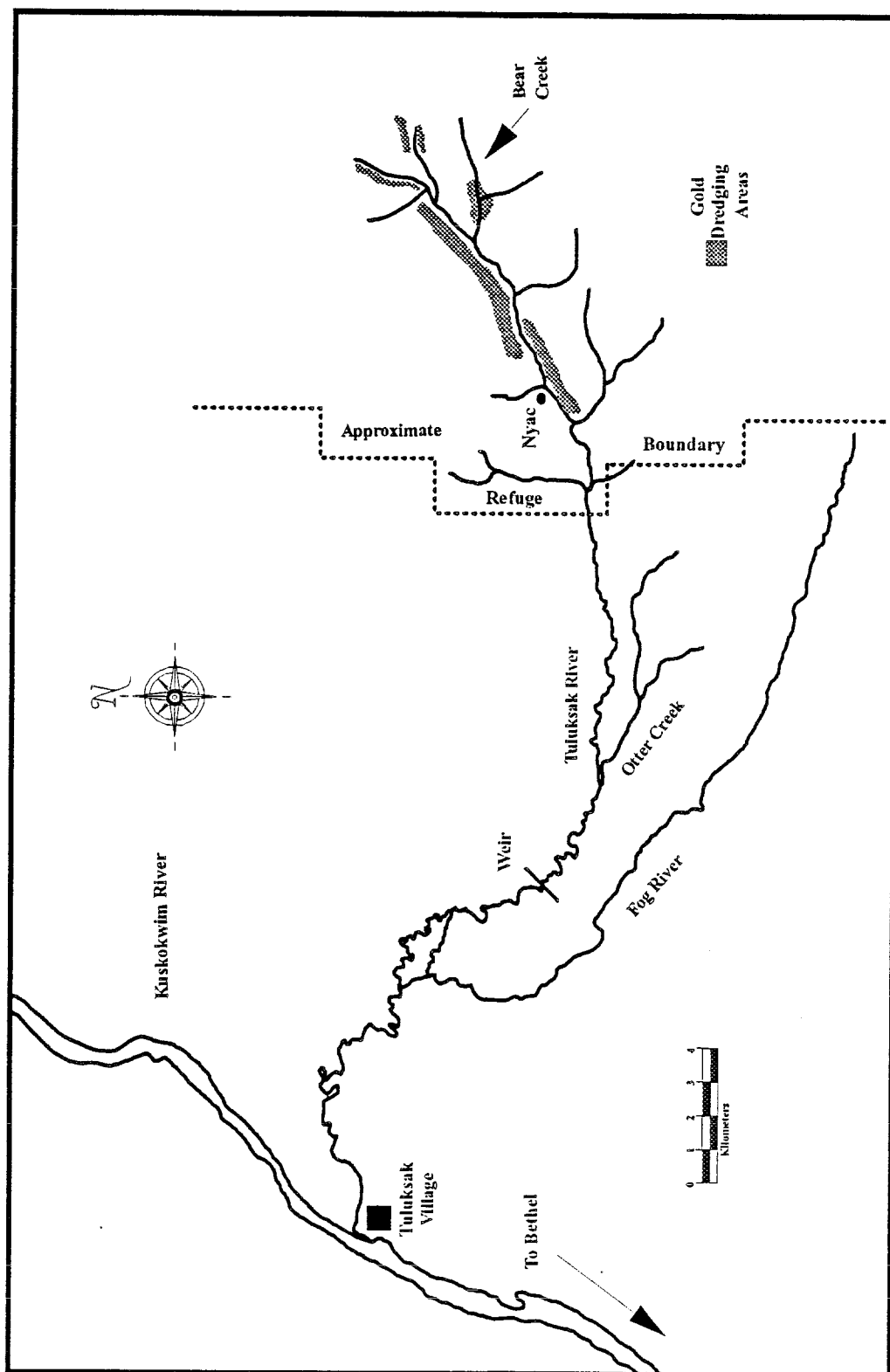


FIGURE 2.—Fish weir location on the Tuluksak River, Alaska, 1991.

33' W) in the Tuluksak River during June 1991. The weir was operated from June 12-September 18, 1991. A staff gauge was installed on the back side of the bulkhead and daily water levels were recorded at 0800 hours each day. Stream discharge was estimated using the method described by Hamilton and Bergersen (1984) with a Marsh-McBirney (Model 201-D) flow meter and top setting wading rod. Water temperatures were measured daily during the middle of the day.

All fish were identified to species, counted, and noted for gill net marks as they passed through the weir. The trap was usually opened at 0700 hours and closed at midnight or earlier depending on the day length. The weir was checked for holes and cleaned daily before 0900 hours. Snorkeling was used to check weir integrity and substrate conditions. Cleaning consisted of walking across each panel until it was partially submerged and letting the current wash the debris downstream. Algal growths were removed by scrubbing with long handled brooms. Spent salmon and carcasses (carcasses) washing up on the weir were counted, identified to species and passed downstream at four hour periods during routine cleaning operations.

Biological Data

Sample weeks or strata started on Sunday and ended the following Saturday. A weekly quota of 160 chum, 140 chinook and 110 coho salmon was sampled at the beginning of each week. Samples were collected in as short a period (1-3 days) as possible to approximate a pulse or snapshot sample (Geiger et al. 1990). All fish within the trap were sampled to prevent bias. A seasonal quota of 40 pink salmon was sampled throughout the season. Once weekly quotas were obtained, the trap was opened and fish were passed until the next sampling period.

Sampled fish were measured, weighed, scales collected for aging, identified to sex using external characteristics, and released upstream. Salmon were measured to the nearest 5 mm mid-eye to fork length and weighed to the nearest 100 g. Gill net marks were noted on each fish. Scales were removed from the preferred area for age determination (Koo 1962, Mosher 1968). One scale was taken from chum and sockeye salmon and four were taken from chinook and coho salmon. Scale impressions were made on cellulose acetate cards using a heated scale press and examined with a microfiche reader. Salmon ages were reported according to the European Method (Koo 1962).

All salmon were aged by two readers. Ages were verified through comparison to commercial catch samples aged by a Department biologist. Mean lengths of males and females by age were compared using Student's t-test ($\alpha=0.05$).

Age and sex composition of the weekly weir passage were estimated using a stratified sampling design (Cochran 1977). Strata were pooled if sufficient samples were not obtained in a single stratum.

Age composition and associated variances for weekly passage were calculated as:

$$\hat{A}_h = N_h p_h; \quad (1)$$

$$\hat{V}[\hat{A}_h] = N_h^2 \left(\frac{p_h(1-p_h)}{n_h-1} \right); \quad (2)$$

\hat{A}_h = the estimated number of fish of a given age and sex during week h ,
 N_h = the number of fish passing in week h ,
 p_h = the proportion of sample in week h of a given age.

Weekly abundance estimates and their variances were summed to obtain age and sex composition estimates for the season as follows:

$$\hat{A}_{st} = \sum \hat{A}_h; \quad (3)$$

$$\hat{V}[\hat{A}_{st}] = \sum \hat{V}(\hat{A}_h); \quad (4)$$

where:

\hat{A}_{st} = the estimated number of fish of a given age for the season.

A z-test comparing the proportion of one sexes age to another was used to determine if age composition differed between the sexes.

Proportions within each sex for a given age was calculated as:

$$\hat{p}_{ij} = \frac{\hat{A}_{st,ij}}{\hat{A}_{st,i}}; \quad (5)$$

where:

i = sex,
 j = age,

$\hat{A}_{st,ij}$ = estimated number of fish of sex i and age j , and

$\hat{A}_{st,i}$ = estimated number of fish of sex i .

The variance was calculated as:

$$\hat{V}(\hat{p}_{ij}) = \hat{p}_{ij}^2 \left[\frac{\hat{V}(\hat{A}_{st,ij})}{\hat{A}_{st,ij}^2} + \frac{\hat{V}(\hat{A}_{st,i})}{\hat{A}_{st,i}^2} \right]; \quad (6)$$

where the variances are the variances calculated per equation (4).

The proportions were considered different if z was greater than the critical value from a Z-table. z was calculated as:

$$z = \frac{\hat{p}_{ij} - \hat{p}_{i'j}}{\sqrt{\hat{V}(\hat{p}_{ij}) + \hat{V}(\hat{p}_{i'j})}}; \quad (7)$$

where:

i' = the other sex.

The sample size was assumed to be large enough to use the Z-distribution. Applying the Bonferroni adjustment, p was significant at the $\alpha=0.05$ level if $p < 0.05/k$, where k was the number of age groups.

Migration Timing

Migration time in days for each salmon species to pass between the test fishery and the weir was estimated. One method used the difference between dates when 50% of the cumulative passage occurred at each location. The second method, used only for chum salmon, examined the effects of commercial harvests on the abundance of chum salmon passing through the weir. Daily weir counts were compared to commercial CPUE data. Commercial CPUE data was plotted on the same axis as daily weir passage, and was shifted ahead one day at a time until the highest number of CPUE points coincided with peaks in daily escapement at the weir. This was fit visually to coincide with the highest agreement between the two events. I assumed that: (1) fish bound for the Tuluksak River were not temporally separated but equally represented in test fishery sampling and commercial fishery harvests, (2) commercial harvests in the lower river removed a proportion of the Tuluksak River fish, which resulted in a depressed number of fish passing the weir for one or several days after the opening.

Stream-life, the amount of time each salmon species spends (residence time) above the weir before washing downstream was similarly estimated. Stream-life was assumed to be the difference between the 50% cumulative passage dates of upstream migration and the downstream passage of carcasses.

Results

Weir Operation

Water levels remained low for most of the year and the weir was never submerged due to high water levels (Appendix 2). Temperatures averaged 11°C between June 12 and September 19, 1991. The maximum temperature was 18°C on June 29. Discharge was measured on August 10 at 14.7 m³/s.

Biological Data

A total of 7,675 chum, 697 chinook, 34 sockeye, 392 pink, and 4,651 coho salmon were counted through the weir between June 12 and September 18, 1991 (Figure 3). Salmon carcasses passed downstream over the weir consisted of 4,376 chum, 167 chinook, 17 sockeye, 730 pink and 13 coho salmon (Appendix 3). Other species counted through the weir included 35 Dolly Varden *Salvelinus malma*, 163 whitefish (*Coregonus pidschian*, *C. nasus* and *Prosopium cylindraceum*), 28 Arctic grayling *Thymallus arcticus*, and 17 northern pike *Esox lucius* (Figure 4, Appendix 3).

Chum salmon.—Chum salmon (N=7,675) were the first salmon counted, passing through the weir on June 19. Peak passage (N=1,622) occurred July 7-13 (Figure 3, Appendix 4). Fifty percent of the migration passed the weir by July 21, 32 days after the first chum salmon passed through the weir (Figure 5, Appendix 4).

Chum salmon escapement was composed of 48% female and 52% male fish distributed among four age-classes, 0.2, 0.3, 0.4, and 0.5 (Table 1). A total of 1,088 chum salmon from the escapement sample (14% of the escapement) was aged. Females and males were predominately age 0.3. Females initially composed less than 50% of the weekly sample, but dominated after August 4 (Figure 6, Appendix 6). Gill net marks (N=361) were observed on 5% of the chum salmon passed (Appendix 3).

Age composition of male and female chum salmon did not differ between sexes (Appendix 6, Bonferroni adjustment $\alpha=0.0125$). Age 0.3 fish composed 58.2% of the chum salmon run followed by age 0.4 (38.0%) fish (Appendix 6).

Males were longer than females in age groups 0.3 (two tailed t-test $t=14.849$, $df=646$, $P<0.001$) and 0.4 (two tailed t-test $t=1028$, $df=418$, $P<0.001$). Sampled males averaged 560 mm and females 512 mm in length. Males averaged 3,237 g (1,000-6,800) and females 2,342 g (1,000-4,700).

A total of 4,376 carcasses were passed downstream over the weir. Carcasses were first seen on July 10, 21 days after chum salmon first passed the weir. Fifty-percent of the carcasses were passed downstream by August 5, 26 days after the first carcass was passed and 15 days after 50% of the upstream migration had occurred (Figure 5, Appendix 5).

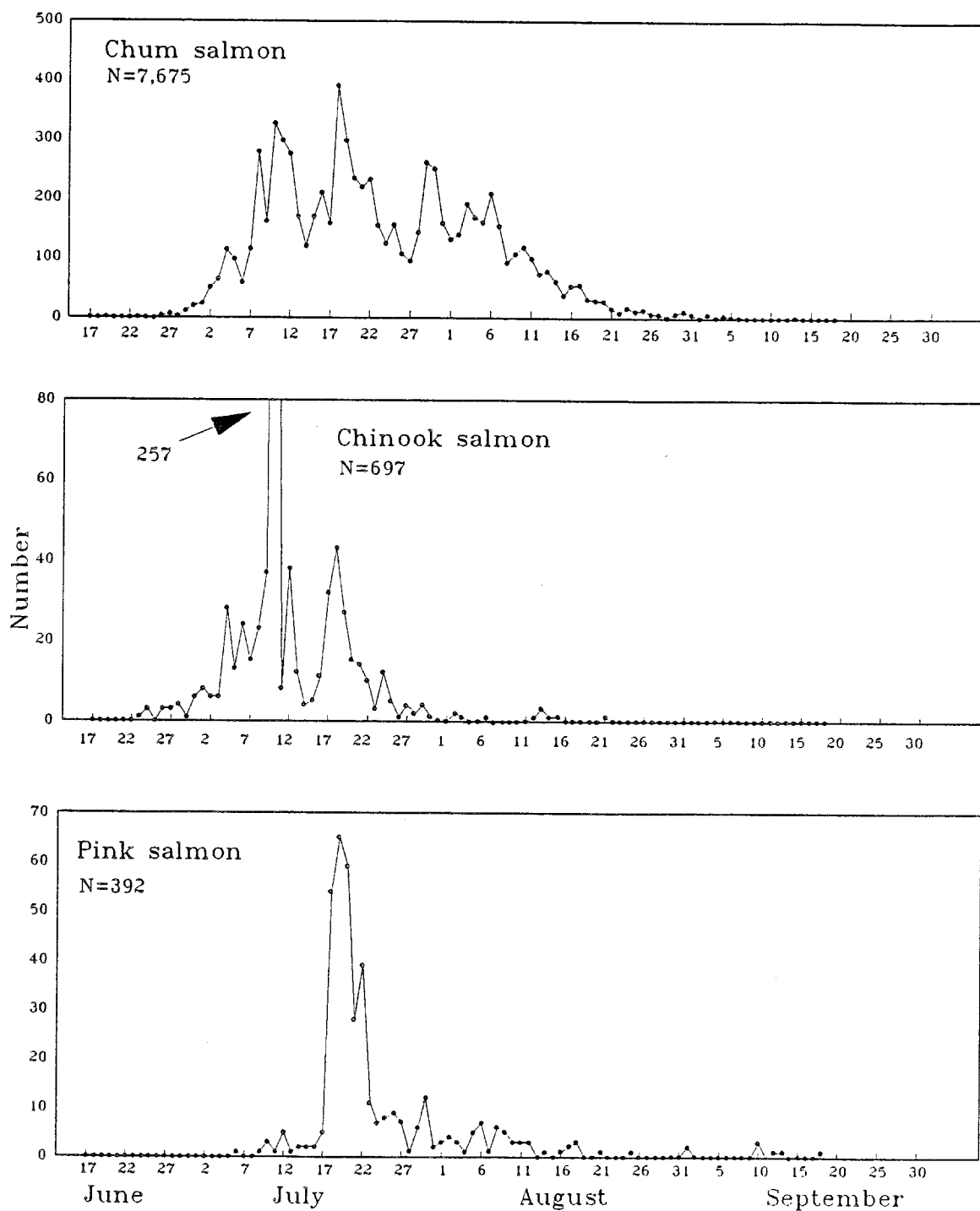


FIGURE 3.-Salmon counted through the Tuluksak River weir, Alaska, June 12-September 18, 1991.

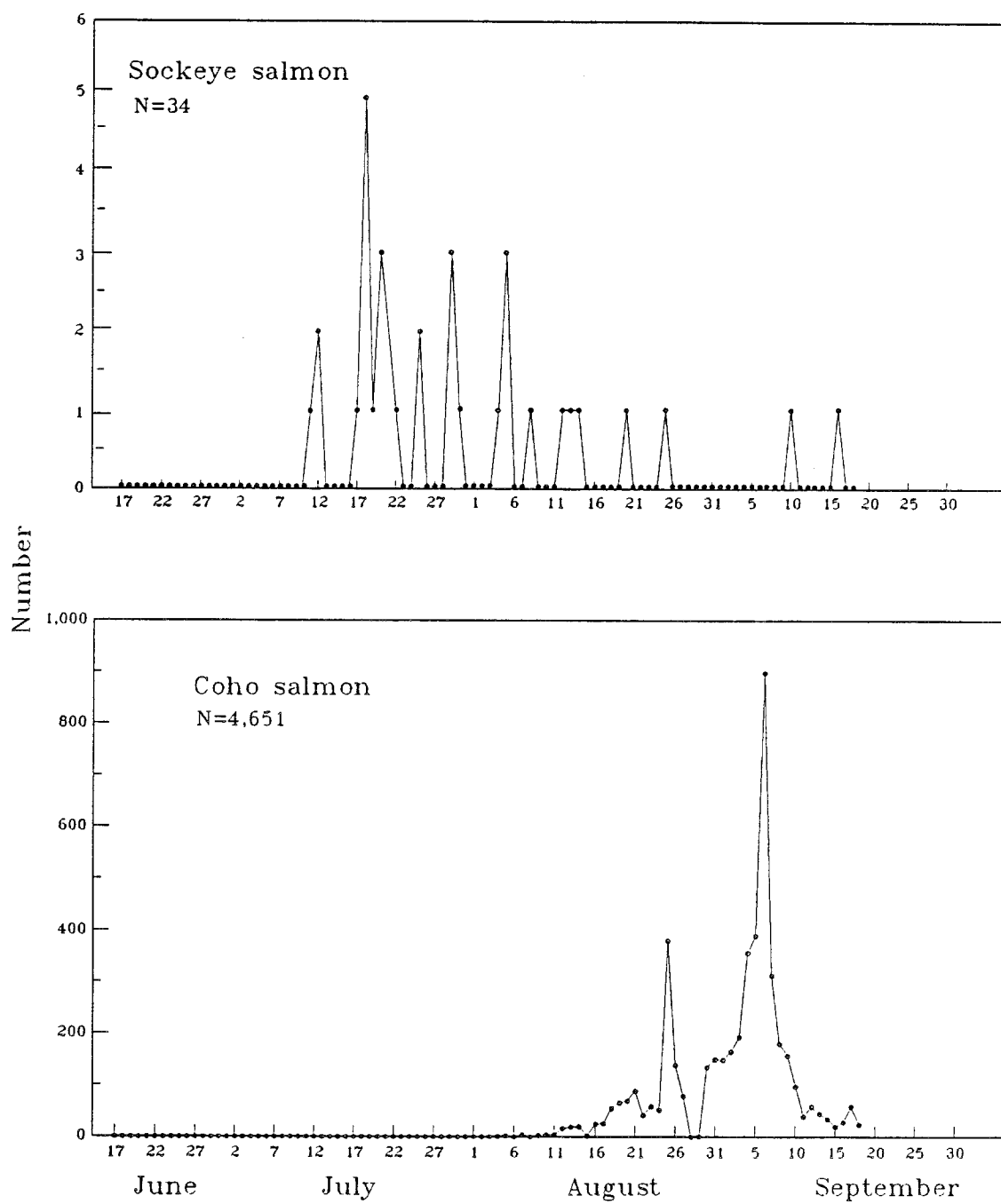


FIGURE 3.--(Continued).

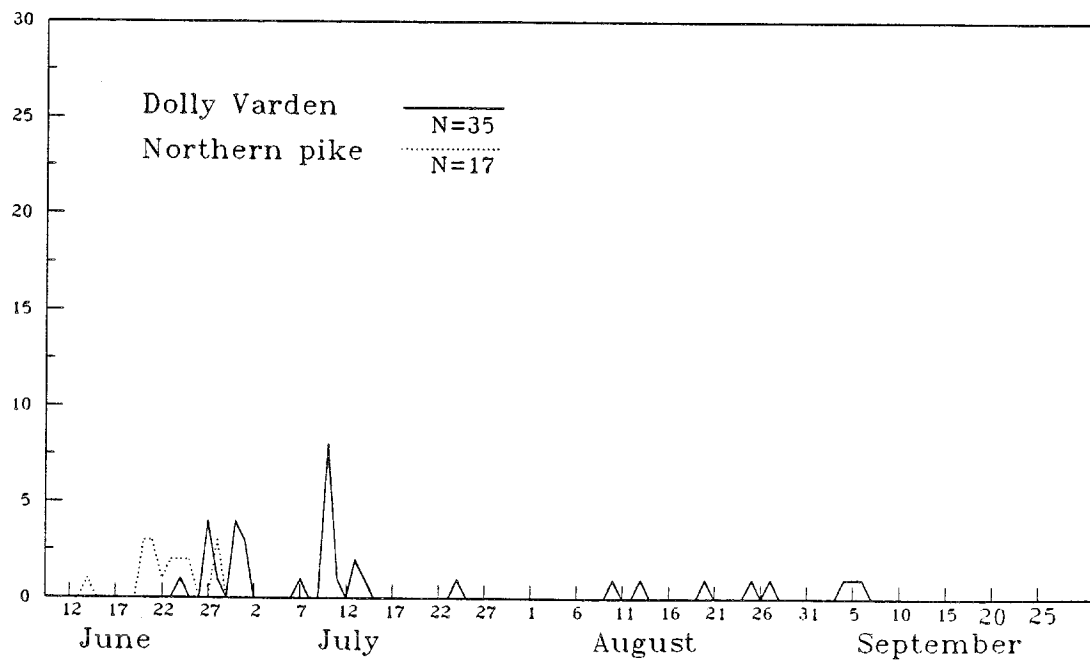
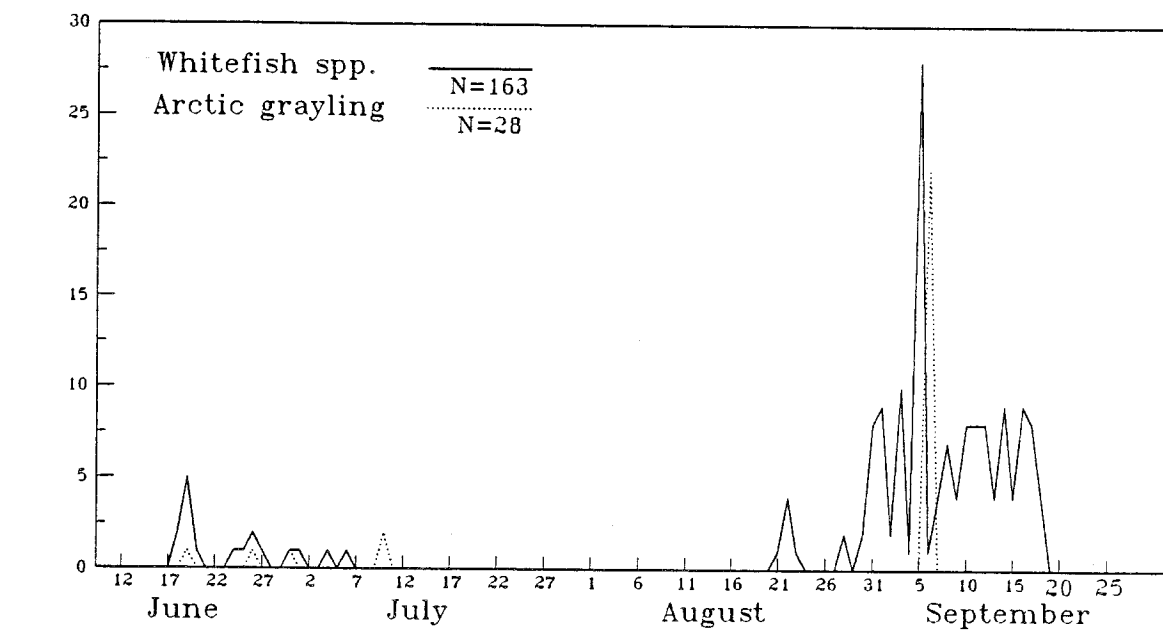


FIGURE 4.-Resident fish counted through the Tuluksak River weir, Alaska, June 12-September 18, 1991.

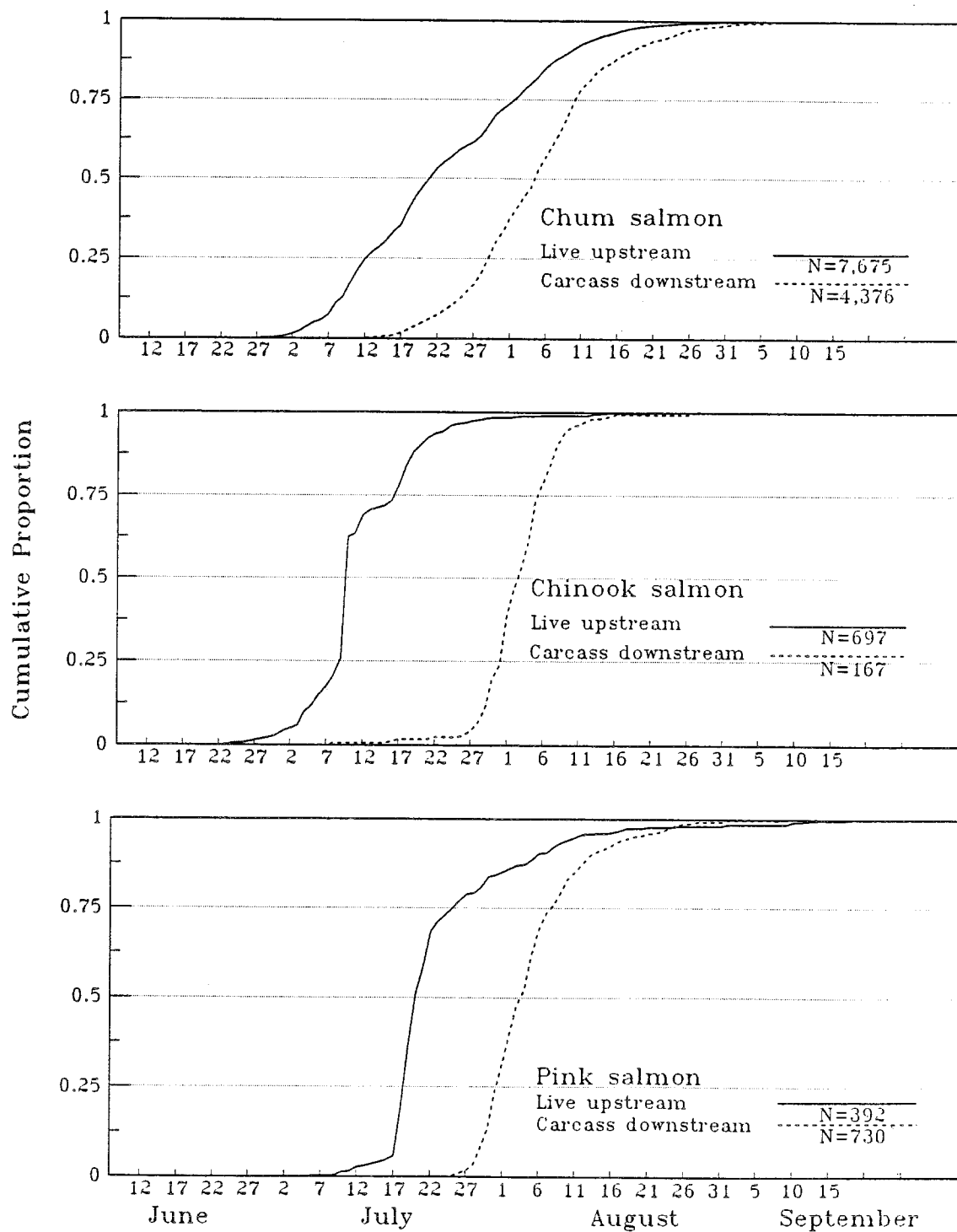


FIGURE 5.-Comparison of cumulative salmon upstream passage and fish carcasses passed downstream, Tuluksak River weir, Alaska, 1991.

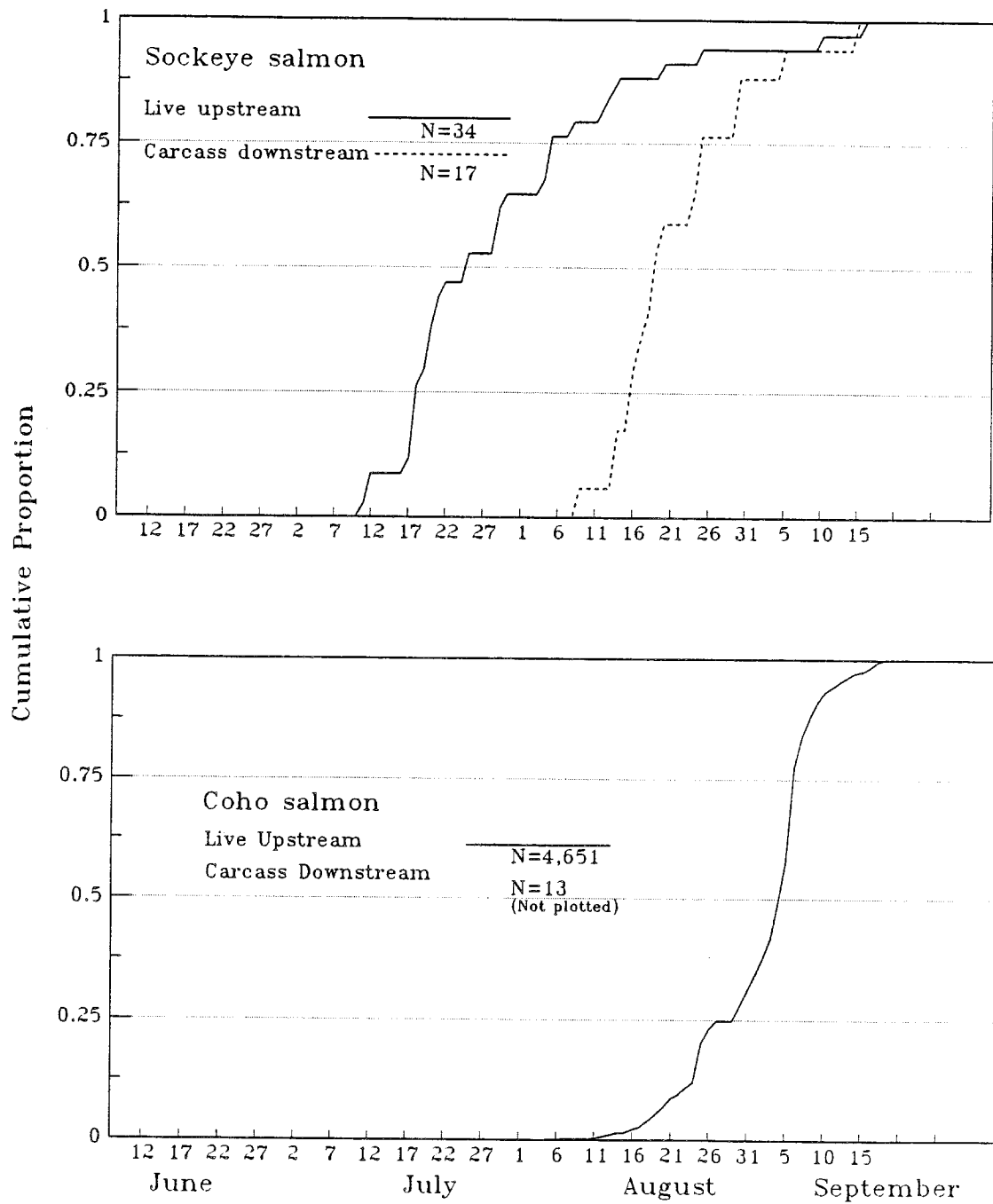


FIGURE 5.-(Continued).

TABLE 1.-Age, length (mid-eye to fork length) and weight composition of chum salmon sampled at the Tuluksak River weir, Alaska, 1991.

Age	N	Length (mm)			Weight (g)		
		Mean	SE	Range	Mean	SE	Range
Female							
0.2	30	484	7	430-550	2,070	84	1,300-3,000
0.3	365	502	34.7	420-590	2,239	23	1,000-4,200
0.4	159	537	3.2	440-680	2,615	44	1,500-4,700
0.5	1	580	-	-	3,500	-	-
Total	555	512		420-680	2,342		1,000-4,700
Male							
0.2	6	518	22	450-575	2,733	322	1,700-3,800
0.3	275	544	36.6	400-665	2,992	39	1,000-5,600
0.4	246	577	0.5	450-685	3,494	49	1,800-6,700
0.5	6	610	13	550-640	4,293	566	2,600-6,800
Total	533	560		400-685	3,237		1,000-6,800

Chinook salmon.-Chinook salmon (N=697) passed the weir starting June 23, four days after the first chum salmon (Figure 3). Peak passage (N=387) occurred the week of July 7-13 (Appendix 7). Fifty percent of the migration passed the weir by July 10, 17 days after the first chinook salmon was passed (Figure 5, Appendix 4).

Nine ages were identified from the 347 chinook salmon scale samples (Table 2). Males were the predominant sex (71.2%) and age groups 1.2, 1.3, and 1.4 were estimated to compose 15.5, 17.7, and 15.5% of the run (Appendix 7). Most of the females were in age groups 1.4 and 1.5 and composed only 17.5 and 5.4% of the total passage. The percentage of females dropped from 66% the week of June 23-29 to approximately 23% between June 30 and July 13 before rebounding to 65% the week of July 21-27 (Figure 6). Females composed 28.8% of the chinook salmon passage, or 201 for the year (Appendix 7).

Lengths of females averaged 854 mm (470-1000 mm) and males averaged 646 mm (370-1,055 mm). Weights of both sexes averaged 7,349 g (900-18,600 g).

Age composition of male and female chinook salmon differed (Appendix 7, Bonferroni adjustment $\alpha=0.005$). Chinook salmon with two years of freshwater growth made up 22.4% of the run. Females lengths were longer

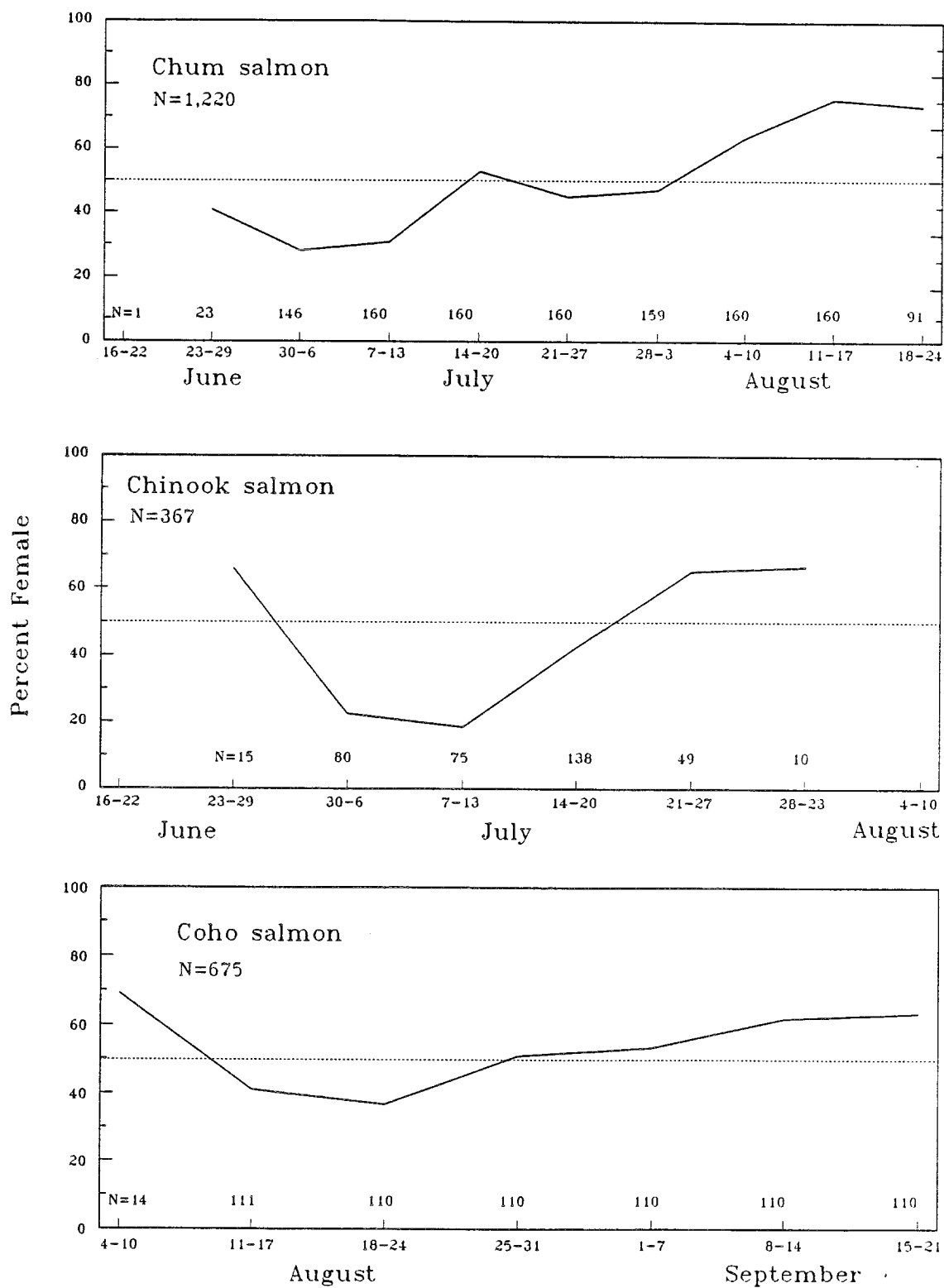


FIGURE 6.-Weekly sex composition (expressed in % females) of salmon sampled at the Tuluksak River weir, Alaska, 1991.

than males in ages 1.3, 1.4, and 2.3 (two tailed t-test age 1.3, $t=3.932$, $df=61$, $P<0.001$; age 1.4, $t=5.364$, $df=121$, $P<0.001$; age 2.3, $t=2.886$, $df=18$, $P<0.01$).

Gill net marks were observed on 9.6% ($N=67$) of the chinook salmon passing the weir and 5.1% of the sampled females (Appendix 3). Gill net marks were noted throughout the season.

Carcasses ($N=167$) were first observed on the weir July 8, 15 days after the first chinook salmon was passed upstream (Figure 5). Fifty percent of the carcasses were passed downstream by August 3, 26 days after the first carcass was passed and 24 days after 50% of the upstream migration had occurred.

TABLE 2.-Age, length (mid-eye to fork length) and weight composition of chinook salmon sampled at the Tuluksak River weir, Alaska, 1991.

Age	N	Length (mm)				Weight (g)			
		Mean	SE	Range		Mean	SE	Range	
Female									
1.2	3	517	18	470-	550	2,600	201	2,400-	3,000
1.3	11	792	10	715-	825	8,636	456	6,300-	10,400
1.4	76	868	6	720-	1,000	11,259	248	6,200-	16,700
1.5	23	884	12	775-	970	11,874	568	7,400-	17,600
1.6	2	905	30	875-	935	13,850	1,550	12,300-	15,400
2.2	1	545	-	-	-	2,760	-	-	-
2.3	4	806	19	755-	845	8,740	761	6,600-	10,100
2.4	6	887	19	840-	960	11,060	750	9,100-	13,900
2.5	3	898	9	880-	910	11,175	618	10,400-	12,400
Total	129	854		470-	1,000	10,828		2,400-	17,600
Male									
1.1	1	370	-	-	-	370	-	-	-
1.2	50	520	8	410-	630	2,282	103	1,000-	4,300
1.3	52	648	16	420-	850	5,095	370	1,200-	10,800
1.4	47	794	15	600-	995	8,717	536	3,400-	17,200
1.5	8	934	39	720-	1,055	13,313	1,451	6,100-	18,600
2.2	37	528	8	420-	630	2,657	172	1,300-	7,100
2.3	16	635	29	440-	815	4,412	540	1,400-	8,700
2.4	5	784	54	580-	885	7,520	1,175	3,100-	9,700
2.5	2	762	58	705-	820	6,750	1,750	5,200-	8,500
Total	218	646		370-	1,055	5,211		1,000-	18,600

Pink salmon.-Pink salmon (N=392) passed the weir starting on July 6, and continued until September 18 (Figure 3). Fifty percent of the upstream migration passed the weir by July 20, 14 days after the first pink salmon was passed (Figure 5).

Twenty-seven pink salmon were sampled. Females (N=11) averaged 420 mm (395-465 mm) in length and 1,173 g (800-1,800 g), and males (N=16) averaged 425 mm (300-480 mm) in length and 1,119 g (800-1,400 g). Lengths of males and female pink salmon did not differ (two tailed t-test, $t=0.491$, $df=25$, $P=0.628$). Gill net marks were observed on five pink salmon passing the weir.

More pink salmon carcasses (N=730) passed downstream over the weir than were counted passing upstream. The first carcass was found on July 25, 19 days after the first pink salmon was passed upstream through the weir (Figure 5). Fifty percent of the carcasses were passed downstream by August 4, 10 days after the first carcass was passed, and 15 days after 50% of the upstream passage had occurred.

Sockeye salmon.-Sockeye salmon (N=34) passed the weir starting on July 11, and continued until September 16 (Figure 3). Fifty percent of the sockeye migration passed the weir by July 25, 14 days after the first sockeye salmon passed (Figure 5).

Five ages were identified from 24 sockeye salmon scale samples. Age 1.3 was the most prevalent age class identified (Table 3). Lengths for both sexes combined averaged 558 mm (440-640 mm) and weights averaged 3,489 g (1,800-5,400 g). Mean lengths and weights at each age were lower for females than for males. Gill net marks were observed on two (6%) of the sockeye salmon passing the weir.

Seventeen sockeye salmon carcasses were passed downstream over the weir (Figure 5). Fifty percent of the carcasses were passed downstream by August 19, 10 days after the first day of carcass passage, and 25 days after 50% of the upstream migration had occurred.

Coho salmon.-Coho salmon (N=4,651) passed the weir starting on August 4. Peak passage occurred the week of September 1-7 when 2,462 were passed (Figure 3). The second highest peak occurred August 25-31 with passage of 884 fish. Coho salmon were still passing the weir at the rate of 24 fish/day on September 18, the day before the weir was removed. Fifty percent of the run had passed the weir by September 5, 32 days after the first coho salmon was passed (Figure 5).

A total of 675 coho salmon were sampled and scale samples from 647 coho salmon were usable and aged. The passage was composed of 52.5% females and 47.5% males distributed among four age classes, 1.1, 2.1, 2.2, 3.1 (Table 4, Appendix 9). Age composition between sexes was different (Appendix 9, Bonferroni adjustment $\alpha=0.0125$). Age 2.1 dominated the four age groups (81.5%). Females and males of that age group composed 43.1% and 38.4% of the run.

TABLE 3.-Age, length (mid-eye to fork length) and weight composition of sockeye salmon sampled at the Tuluksak River weir, Alaska, 1991.

Age	N	Length (mm)			Weight (g)		
		Mean	SE	Range	Mean	SE	Range
Female							
1.2	2	528	8	510-535	2,300	100	2,300-2,500
1.3	2	498	20	460-500	2,400	600	1,800-3,000
1.4	1	500	-	-	2,300	-	-
2.2	1	535	-	-	2,700	-	-
2.3	2	565	15	550-590	3,550	250	3,300-3,800
Total	8	523		510-590	2,713		1,800-3,800
Male							
1.2	5	566	6	555-590	3,500	202	3,000-4,000
1.3	6	597	14	545-640	4,333	495	2,400-5,400
2.2	3	573	28	530-625	3,400	503	2,800-4,400
2.3	2	560	-	-	3,550	250	3,300-3,800
Total	16	578		530-640	3,800		2,400-5,400

Mean lengths of females were longer than males at age 2.1 (two tailed t-test, $t=2.250$, $df=539$, $P<0.025$). Weights averaged 2,839 g (1,000-5,500 g) and lengths averaged 522 mm (390-695 mm). The percentage of females dropped below 50% the weeks of August 11-17, and 18-24; the exception was the first week when they composed 70% of the 14 fish sampled (Figure 6).

Gill net marks ($N=435$) were found on 9% of the coho salmon passed. Only 13 coho salmon carcasses were passed downstream over the weir.

One coho salmon tagged in the Gulf of Alaska was recovered at the weir on August 27. The fish (tag number CC9033) was a male, 510 mm, and was age 2.1.

TABLE 4.-Age, length (mid-eye to fork length) and weight composition of coho salmon sampled at the Tuluksak River weir, Alaska, 1991.

Age	N	Length (mm)			Weight (g)		
		Mean	SE	Range	Mean	SE	Range
Female							
1.1	2	498	8	490-505	2,500	200	2,300-2,700
2.1	279	527	2	405-625	2,843	40	1,300-4,900
2.2	9	507	16	415-575	2,466	284	1,200-4,000
3.1	44	535	6	390-590	2,929	95	1,500-4,100
Total	334	527		390-625	2,843		1,200-4,900
Male							
1.1	5	470	33	395-570	2,360	412	1,600-3,900
2.1	262	517	3	395-695	2,816	55	1,000-5,500
2.2	11	522	14	430-585	2,818	200	1,900-4,100
3.1	35	538	9	405-595	3,125	147	4,700-4,700
Total	313	519		395-695	2,843		1,000-5,500

Migration Timing

The difference between the dates when 50% of the salmon had passed both the test fishery and the weir was 10 days for chum, 15 days for chinook, 26 days for sockeye, and 25 days for coho (Figure 7). Pink salmon data were not available from the test fishery. Estimated swimming speeds to cover the 169 km distance in km/d were: 17 for chum, 11 for chinook, 7 for sockeye, and 7 for coho salmon.

Peak days in the daily escapement data coincided with an 11 day lag from the commercial opening for chum salmon (Figure 8). The swimming speed using this estimate would range between 15 and 20 km/d.

The run timing for 90% of each salmon species to pass the weir varied as follows: chum 52 days, chinook 27 days, sockeye 40 days, pink 41 days, and coho 36 days. Estimated stream-life for salmon above the weir was: 15 days for chum, 24 days for chinook, 24 days for sockeye, and 15 days for pink salmon. Only 13 coho salmon carcasses were passed downstream and stream-life was not estimated for this species.

Aerial Survey

An aerial index survey of the Tuluksak River on July 24, enumerated 358 chinook and 1,314 chum salmon, and the September 3 survey counted

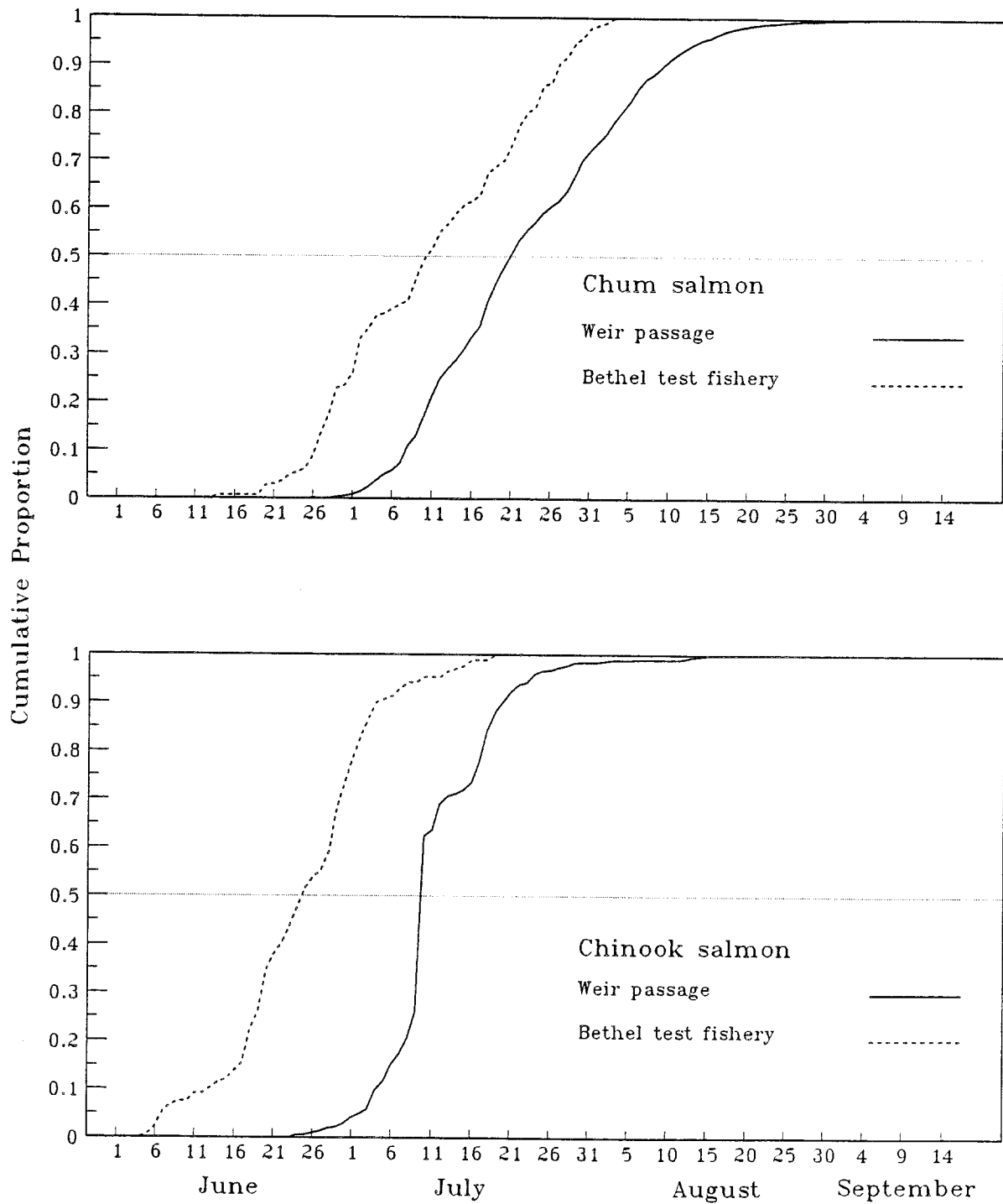


FIGURE 7.-Cumulative daily passage at the Tuluksak River weir, and at the Bethel test fishery, Alaska, 1991.

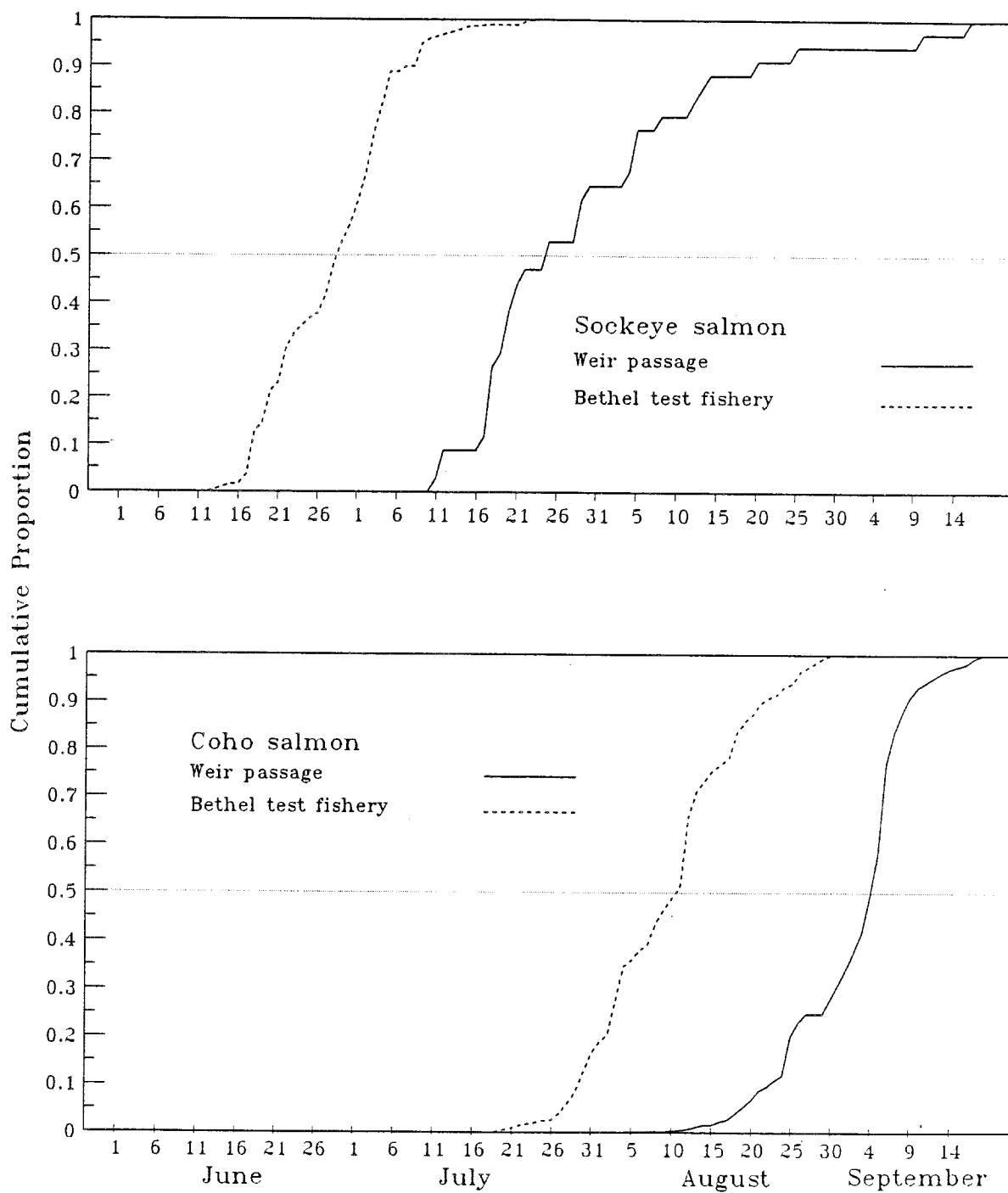


FIGURE 7.--(Continued).

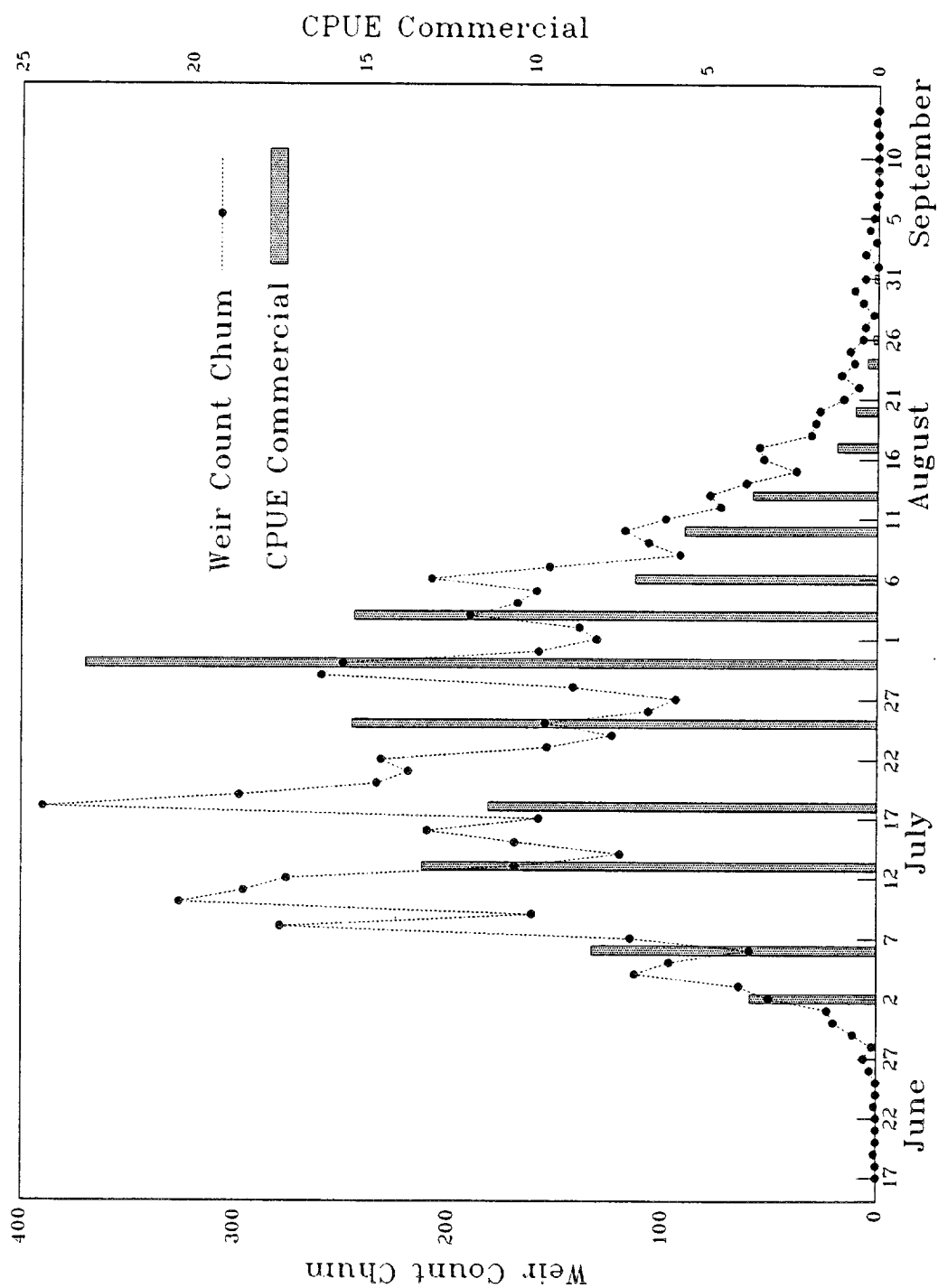


FIGURE 8.--Comparison of run timing for chum salmon in the Tuluksak River and catch per unit of effort (CPUE) in the lower Kuskokwim River commercial fishery, Alaska. CPUE data is plotted 11 days after the actual date.

1,022 coho salmon and no chum salmon (Francisco et al. 1992). Both surveys were conducted under optimal weather and water clarity conditions. The July survey was completed when 57% of the chum and 96% of the chinook were past the weir. The September survey was completed when 41% of the coho salmon were past the weir. Approximately 10% of the chum, 2% of the chinook and no coho carcasses were passed downstream at the time of the aerial index surveys.

Discussion

The resistance board weir was established on June 12, several days before the first salmon were counted, suggesting that the weir was deployed before salmon reached the weir site. Coho salmon were still passing the weir at the rate of 24 per day on September 18, the last day of operation. This daily passage represents less than 1% of the cumulative passage and the peak occurred on September 6 with a reduction of fish passing the weir each day after. Counts of other salmon species had also declined to less than 1% of the cumulative passage or had not been observed for several days prior to the removal of the weir, suggesting that the majority of these runs had passed. Based upon one boat survey, I estimated that less than 40 chinook and 230 chum salmon spawned below the weir in the Tuluksak River. The spacing between pickets allowed small fish to pass through undetected. Some resident fish that were in the trap moved freely through the pickets when an attempt was made to net them. Therefore, only the larger individuals are represented in the numbers of resident fish. Small pink salmon also slipped through the weir undetected because more carcasses were passed downstream than the number counted upstream.

Biological Data

Chum salmon.—Chum salmon run timing in the Tuluksak River was similar to that found at the Aniak River sonar and Kogrukluk River weir where they passed from mid to late June (Schneiderhan 1988; Burkey 1991; and Francisco et al. 1991). Females in the Tuluksak River made up 48% of the fish passage compared to 55% in the 1991 Kuskokwim River commercial fishery harvest (Department files). Both the weir and commercial fishery samples had a higher percentage of males early in the run.

Chinook salmon.—During 1991, chinook salmon ($N=697$) exceeded the aerial index survey objective of 400 fish by 74%. The aerial survey index ($N=358$) was only 51% of the weir passage. The percentage of females at the weir (28.8%) was less than the percentage in the 1991 Kuskokwim River commercial catch (32%), or the Kogrukluk River weir (46.6%). The percentage was similar to the 1985-1990 average returns (29%) to the Kogrukluk River weir (Department files). The 1991 return to the Kogrukluk River weir was the highest since 1981. An estimated total return of 201 females passed Tuluksak River weir.

Several factors may explain the low number of females relative to males passing the weir. Females return at older ages than males, incurring additional years of ocean mortality and high seas harvests

(Hankin and Healy 1986). The subsistence fishery, which allows larger mesh nets than the commercial fishery, also harvests larger fish including older age females that predominate the larger sizes (Francisco et al. 1991). The chinook salmon run is also small and occurs in a mixed stock fishery with chum salmon.

The percentage of sampled female chinook salmon that were gill net marked (5.1%) was lower than the 1985-91 average of 16.9% (13.3%-19.4%) found at the Kogrukluk River weir (Francisco et al. 1992). The lower percentage of net marked females in the Tuluksak River may be the result of a higher exploitation rate in both the subsistence and commercial fishery before reaching the Tuluksak River weir. Females that drop out of commercial fishery nets may be harvested in subsistence fisheries, reducing both the percentage of females and net marks.

Pink salmon.-Kuskokwim River pink salmon have strong even year runs (Francisco et al. 1992). The downstream passage of 730 carcasses was substantially higher than the 392 passed upstream. Smaller pink salmon are suspected of passing between the pickets. The upstream passage of 392 pink salmon at the Tuluksak River weir was greater than any year at the Kogrukluk River weir where the high passage was only 19. This difference may be due to the greater distance from the mouth of the Kuskokwim River to the Kogrukluk River weir. There are no directed commercial openings for pink salmon, however, commercial catches in the Kuskokwim River have averaged 3,948 for even years and 217 for odd years since 1980 (Francisco et al. 1992). There is no escapement goal for pink salmon in the Kuskokwim River drainage.

Sockeye salmon.-Little is known about the Tuluksak River sockeye salmon population. The Holitna River, a tributary of the Kuskokwim River, is the only system that has an escapement objective for sockeye salmon. The escapement objectives are 2,000 at the Kogrukluk River weir and 1,000 from aerial surveys below the weir (Francisco et al. 1992). Additional years of data are needed from the Tuluksak River to determine the stability of the population. Lake habitat that will support a larger population is not present in the Tuluksak River.

Coho salmon.-Few aerial index surveys have been conducted on the Tuluksak River to compare with the 1991 escapement ($N=4,561$) (Schneiderhan 1983, 1988; Francisco et al. 1992). The 1991 aerial survey index ($N=1,314$) was the largest of three surveys conducted in 1978, 1983, and 1991. The two previous coho surveys were considered poor in quality due to weather or visibility conditions.

The sex composition at the weir was similar to the commercial fishery samples. Females composed 41% of the commercial catch samples (Department files) and 47.4% of the Tuluksak River escapement.

Coho salmon movement past the weir may have been influenced by fluctuating water levels. Rising water levels from September rains appeared to trigger upstream movements of coho salmon.

Information on the tagged coho salmon was provided by the Fishery Research Institute, University of Washington. The coho salmon was originally tagged on July 6, 1991 in the Gulf of Alaska (52° 44' N Latitude, 151° 57' W Longitude). During 52 days at large, the coho salmon migrated approximately 1,600 km.

Four additional tag recoveries were from fish tagged in the same transect: one coho salmon in the Cook Inlet commercial salmon fishery, two coho salmon in the Kodiak Island commercial fishery, and one pink salmon at a Prince William Sound hatchery. This suggests mixing of various stocks and species in the Gulf of Alaska.

Migration Timing

The migration time for salmon passing through the commercial fishery, can play an important role in making in-season management decisions. Management can spread the harvest across several fishing periods to prevent the overharvest of individual stocks and allow adequate escapements.

Tagging studies conducted by the Department in 1961, 1962, and 1966 found that chum salmon swimming speeds averaged 19.5 km/d (range 5.4-76.8 km/d) in the Kuskokwim River (Francisco et al. 1992). Chum salmon swimming at these rates take between 2.2 and 31 days to reach the Tuluksak River weir from Bethel.

The migration time for chinook and chum salmon using the 50% cumulative passage at the test fishery and the weir fall within the range found in tagging experiments on the Kuskokwim River (Marino and Otis 1989; Francisco et al. 1992). Migration rates for salmon returning to the Tuluksak River were estimated as 17 km/d for chum, 11 km/d for chinook, 7 km/d for sockeye, and 7 km/d for coho. Chum salmon swimming at this speed would pass through the lower Kuskokwim River fisheries faster than chinook salmon but slower than sockeye and coho salmon. If chinook salmon swim 11 km/d from the time they enter the Kuskokwim River, until they enter the Tuluksak River they would be vulnerable to harvest for 20 days.

Chum salmon bound for the Tuluksak River appeared to be mixed throughout the run in the lower Kuskokwim River. Each commercial opening appeared to reduce chum salmon numbers passing the weir approximately 11 days later. Delays between commercial openings allowed fish to escape from all segments of the run. By comparing commercial openings to subsequent reductions of weir passage, the estimated swimming speed was similar to the cumulative passage estimate. Because the commercial harvest data is from the mouth of the Kuskokwim River to the village of Tuluksak, a distance of 218 rkm, it is impossible to determine the exact location where the chum salmon were harvested, but the swimming speed falls within the estimate from previous tagging studies. A tagging study with additional monitoring stations such as weirs would provide better data on swimming speeds.

Estimating stream-life above the weir by comparing the upstream passage and downstream passage of carcasses appeared to be acceptable for 1991. The cumulative proportion curves for upstream passage of spawners and downstream passage of carcasses were not tested but appeared to be similar in shape (Figure 5). Different cumulative proportion curves would indicate different run timing distributions. The use of carcass counts has several drawbacks that may affect the accuracy of the estimate. Nielson and Geen (1981), found residence time on redds to vary throughout the season. Early arriving salmon generally spend a longer period on a redd than late arrivals. Rising water levels can also wash fish downstream faster than normal. The distance the fish spawn above the weir or counting area can also affect counts, and the entire population is not represented. Carcasses, however, represented up to 1/3 of the upstream passage of salmon. A tagging study would provide accurate information on stream-life above the weir.

Aerial Survey

Aerial index surveys must account for stream-life and run timing to provide useful data. Species, like chum salmon, with a short stream-life and protracted escapements should be surveyed more than once and the "Factor 5" or "Area Under the Curve" methods (Cousins et al. 1982) used to estimate total abundance. Species with long stream-life and short immigration time such as chinook salmon can be surveyed once with a large percentage of spawners observed. In the Tuluksak River by July 24, 1991, over 96% of the chinook salmon had passed the weir, and 2% of the carcasses had been passed downstream. This left 94% of the total chinook salmon run available during the aerial index survey. Surveys flown later would have had a higher percentage of carcasses to subtract from the live counts. A survey flown on July 31 would account for over 98% of the run that had passed the weir, however, approximately 23% of the carcasses had been passed downstream by that date. Biological data is not collected during aerial index surveys. Because female chinook salmon returning to the Tuluksak River mature at older ages than males and constitute a smaller percentage of the run it is important to gather data on the quality of the escapement.

Recommendations

Based upon the data in this report and personal observations, the following is recommended:

1. Continue the weir operation for at least one full life cycle of chinook salmon to determine if chinook salmon sex ratios are cyclical.
2. Conduct a tagging study to determine swimming speed of Tuluksak River stocks.
3. Collect spawning and rearing habitat data to quantify the rivers carrying capacity and establish biological escapement goals for chinook, chum and coho salmon.

Acknowledgements

Special appreciation is extended to those people who contributed to this project: Brad Benter, crew leader, for data collection and day to day weir operation, and co-workers Doug Palmer, Jeff Booth and John Tobin, and Student Conservation Volunteers Anna Gitman and Vladimir Duret. Anne Barrett for typing the manuscript and drawing of figures.

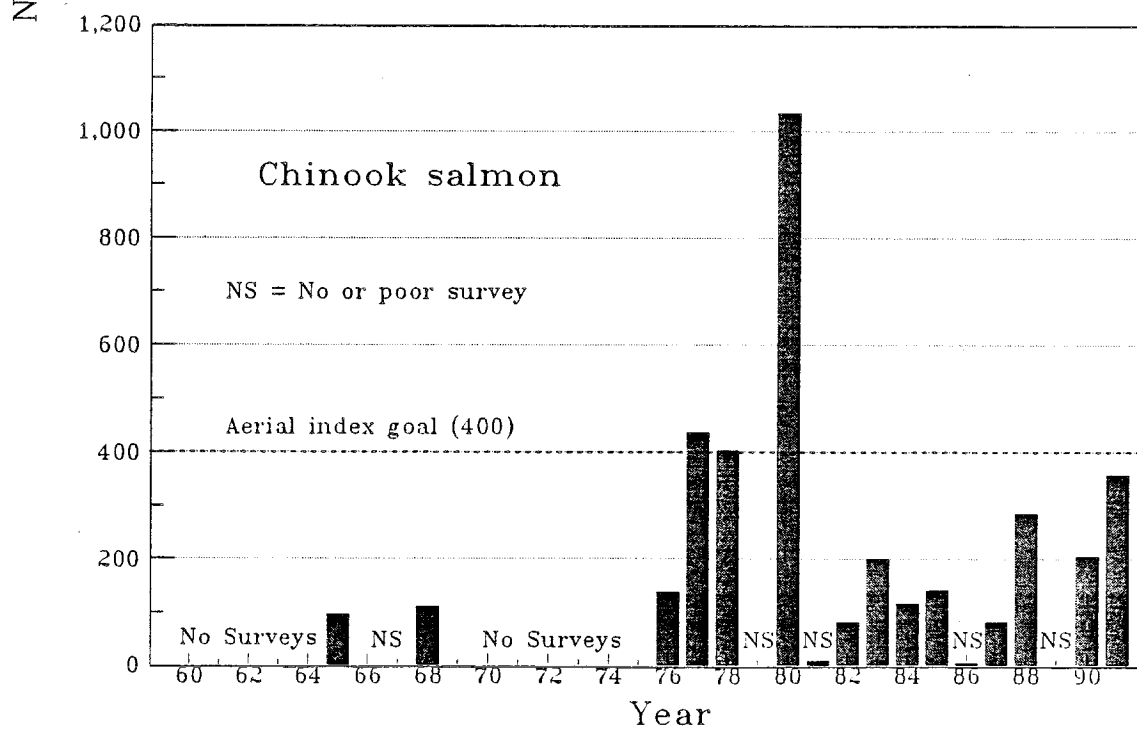
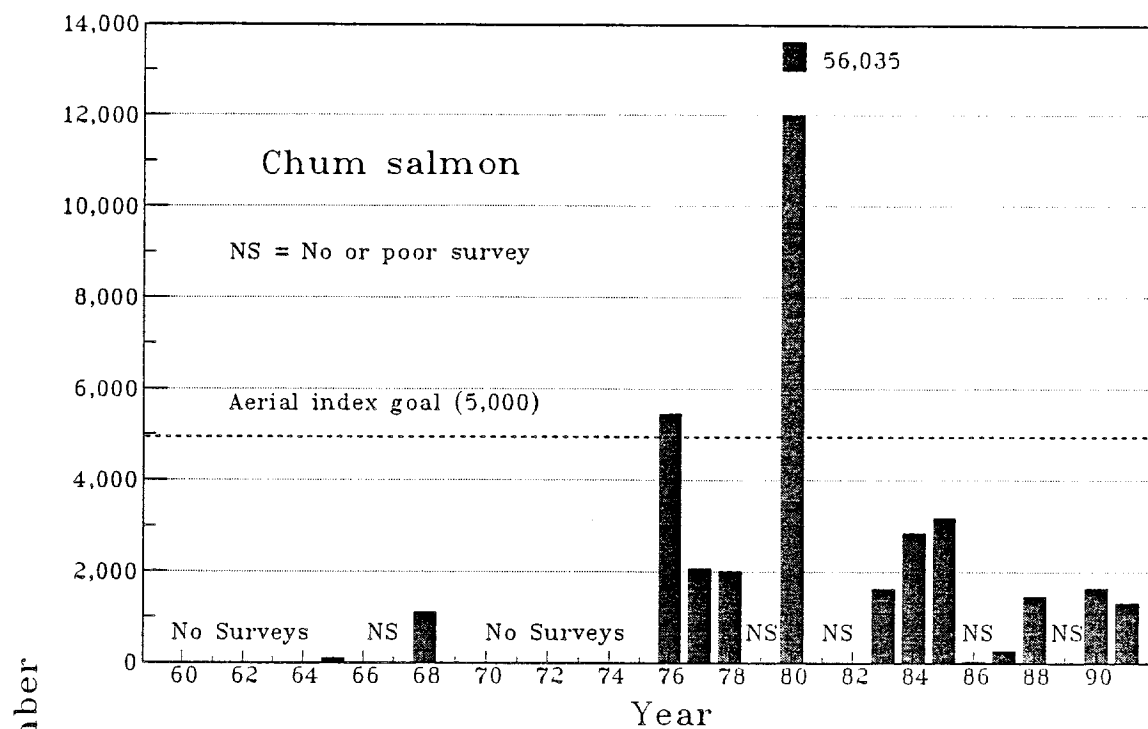
A special thanks also to the entire Yukon Delta National Wildlife Refuge staff. Ron Perry, Denny Strom, John Morgart, Mike Jensen, and Mildred Prince and many others deserve special mention for their help and assistance. We also appreciate the help and assistance of the Alaska Department of Fish and Game (Commercial Fish Division, Bethel Office) and to Doug Molyneaux for assisting with aging of salmon scales.

References

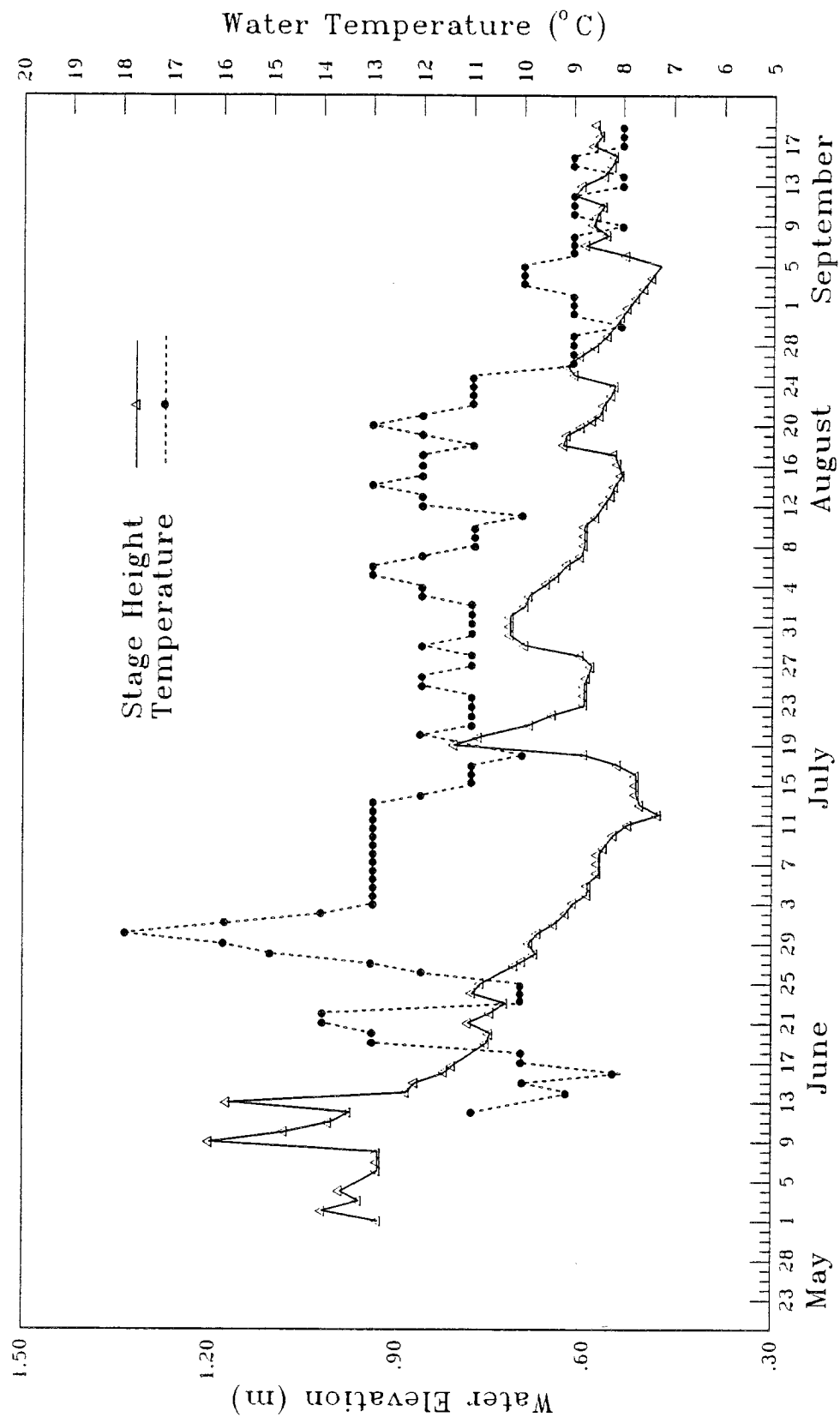
- Alt, K. 1977. Inventory and cataloging in western Alaska waters. Alaska Department of Fish and Game, Federal Aid in Fish Restoration Completion Report, Study G-I-P, Volume 18, Juneau, Alaska.
- Burkey, C. Jr. 1991. Kogrukluks weir escapement report, 1990. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYC Region, Regional Information Report No. 3B91-19, Anchorage, Alaska.
- Cochran, W.G. 1977. Sampling techniques, third edition. John Wiley and Sons, New York.
- Cousins, N.B.F., G.A. Thomas, C.G. Swann, and M.C. Healey. 1982. A review of salmon escapement estimation techniques. Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, British Columbia.
- Crayton, W.M. 1990. Report of findings, placer mining impacts - Tuluksak River, fiscal years 1987, 1988 and 1989. U.S. Fish and Wildlife Service, Ecological Services, Anchorage, Alaska.
- Francisco, K.R., C. Anderson, C. Burkey, M. Coffing, K. Hyer, D. Molyneaux, and C. Utermohle. 1992. Annual management report for the subsistence and commercial fishery of the Kuskokwim area, 1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report 3A92-06, Anchorage, Alaska.
- Francisco, K.R., C. Burkey, D. Molyneaux, C. Anderson, H. Hamner, K. Hyer, M. Coffing, and Charles Utermohle. 1993. Annual Management Report Kuskokwim Area, 1990. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report Number 3B91-11, Anchorage, Alaska.
- Francisco, K.R., C. Anderson, C. Burkey, M. Coffing, K. Hyer, D. Molyneaux, and C. Utermohle. 1994. Annual Management Report Kuskokwim Area, 1993. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report Number 3A94-21, Anchorage, Alaska.
- Francisco, K.R., and K.A. Sundberg. 1983. Tuluksak River fisheries reconnaissance survey with special emphasis on the effects of gold dredging. Alaska Department of Fish and Game, Arctic-Yukon-Kuskokwim Region, Kuskokwim Inventory Report Number 6, Bethel, Alaska.

- Geiger, J.H., J.E. Clark., B. Cross, and S. McPherson. 1990. Report from the Work Group on Sampling. Pages 3-12 in H.J. Geiger, and R.L. Wilbur, editors. Proceedings of the 1990 Alaska Stock Separation Workshop. Alaska Department of Fish and Game, Division of Commercial Fisheries. Special Fisheries Report No. 2. Juneau, Alaska.
- Hamilton, K., and E.P. Bergersen. 1984. Methods to estimate aquatic habitat variables. Colorado State University, Colorado Cooperative Fishery Research Unit, Ft. Collins, Colorado.
- Hankin D.G., and M.C. Healy. 1986. Dependence of exploitation rates for maximum yield and stock collapse on Age and sex structure of chinook salmon (*Oncorhynchus tshawytscha*) stocks. Canadian Journal of Fisheries and Aquatic Sciences Vol. 43:1746-1759.
- Koo, T.S.Y. 1962. Age determination in salmon. Pages 37-48 in T.S.Y. Koo, editor. Studies of Alaskan Red Salmon. University of Washington Press, Seattle, Washington.
- Marino, T., and T. Otis. 1989. Pilot inventory of the chinook salmon (*Oncorhynchus tshawytscha*) stocks of the Kuskokwim River basin, Yukon Delta National Wildlife Refuge, 1989. U.S. Fish and Wildlife Service unpublished manuscript, Bethel, Alaska.
- Mosher, K.H. 1968. Photographic atlas of sockeye salmon scales. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Fishery Bulletin 2:243-274.
- Mundy, P.R. 1982. Computation of migratory timing statistics for adult chinook salmon in the Yukon River, Alaska, and their relevance to fishery management. North American Journal of Fisheries Management 4:359-370.
- Nielson, J.D., and G.H. Geen. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Transactions of the American Fisheries Society 110: 554-556.
- Schneiderhan, D. 1979. 1978 Kuskokwim River sonar studies. Alaska Yukon-Kuskokwim Region. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim River Escapement Report Number 16, Anchorage, Alaska.
- Schneiderhan, D. 1983. Kuskokwim stream catalog, 1954-1983. Alaska Department of Fish and Game, unpublished annotated database report, Anchorage, Alaska.
- Schneiderhan, D. 1988. Kuskokwim area salmon escapement observation catalog, 1984-1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Informational Report Number 3B88-29, Anchorage, Alaska.

- Tobin, J.H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Technical Report Number 22, Kenai, Alaska.
- U.S. Fish and Wildlife Service. 1988. Yukon Delta National Wildlife Refuge comprehensive conservation plan, environmental impact statement, wilderness review, and wild river plan. U.S. Department of Interior, Fish and Wildlife Service, Anchorage, Alaska.
- U.S. Fish and Wildlife Service. 1992. Fishery management plan for the Yukon Delta National Wildlife Refuge. U.S. Fish and Wildlife Service, Anchorage, Alaska.
- Zar, J.H. 1984. Biostatistical analysis, second edition. Prentice and Hall, Englewood Cliffs, New Jersey.



APPENDIX 1.-Aerial index surveys for chinook and chum salmon in the Tuluksak River, Alaska, 1960-1991.



APPENDIX 2.-Water elevation and temperatures in the Tuluksak River, Alaska, 1991.

APPENDIX 3.--Total daily weir counts of anadromous, anadromous gill net marked, and resident fish species, Tuluksak River, Alaska, 1991.

Date	Gill net marked										Arctic Northern pike
	Chinook salmon	Chum salmon	Sockeye salmon	Pink salmon	Coho salmon	Chinook salmon	Chum salmon	Sockeye salmon	Pink salmon	Coho salmon	Arctic Northern pike
6/12	0	0	0	0	0	0	0	0	0	0	0
6/13	0	0	0	0	0	0	0	0	0	0	0
6/14	0	0	0	0	0	0	0	0	0	0	1
6/15	0	0	0	0	0	0	0	0	0	0	0
6/16	0	0	0	0	0	0	0	0	0	0	0
6/17	0	0	0	0	0	0	0	0	0	0	0
6/18	0	0	0	0	0	0	0	0	0	0	0
6/19	0	1	0	0	0	1	0	0	0	0	1
6/20	0	0	0	0	0	0	0	0	0	0	3
6/21	0	0	0	0	0	0	0	0	0	0	3
6/22	0	0	0	0	0	0	0	0	0	0	1
6/23	1	1	0	0	0	0	0	0	0	0	2
6/24	3	0	0	0	2	0	0	0	0	1	2
6/25	0	0	0	0	0	0	0	0	0	0	2
6/26	3	3	0	0	0	0	0	0	0	0	1
6/27	3	6	0	0	0	1	0	0	0	4	0
6/28	4	2	0	0	1	0	0	0	0	1	3
6/29	1	11	0	0	0	0	0	0	0	0	0
6/30	6	20	0	0	0	0	0	0	0	4	1
7/01	8	23	0	0	2	0	0	0	0	3	0
7/02	6	50	0	0	0	0	0	0	0	0	0
7/03	6	64	0	0	0	1	0	0	0	0	0
7/04	28	113	0	0	3	3	0	0	0	0	1
7/05	13	97	0	0	0	0	0	0	0	0	0
7/06	24	59	0	1	1	1	0	0	0	0	0
7/07	15	115	0	0	1	3	0	0	0	1	0
7/08	23	279	0	0	2	5	0	0	0	0	0
7/09	37	161	0	1	3	7	0	0	0	0	0
7/10	254	326	0	3	21	11	0	0	0	8	0
7/11	8	296	1	1	1	5	0	0	0	1	2
7/12	38	276	2	5	0	8	0	0	0	0	0
7/13	12	169	0	1	0	3	0	0	0	2	0
7/14	4	120	0	2	0	2	0	0	0	1	0
7/15	5	169	0	2	0	2	0	0	0	0	0
7/16	11	210	0	2	0	3	4	0	0	0	0
7/17	32	158	1	5	0	6	1	0	0	0	0
7/18	43	390	5	54	0	8	15	1	0	0	0

APPENDIX 3.-(Continued).

Date	Gill net marked											Arctic Northern grayling pike
	Chinook salmon	Chum salmon	Sockeye salmon	Pink salmon	Coho salmon	Chinook salmon	Chum salmon	Sockeye salmon	Pink salmon	Coho salmon	Dolly Varden	
7/19	27	298	1	65	0	4	20	0	2	0	0	0
7/20	15	234	3	59	0	1	4	0	0	0	0	0
7/21	14	219	2	28	0	2	9	0	0	0	0	0
7/22	10	232	1	39	0	2	14	0	0	0	0	0
7/23	3	154	0	11	0	0	9	0	0	0	0	0
7/24	12	124	0	7	0	0	5	0	0	0	1	0
7/25	5	155	2	8	0	0	4	0	1	0	0	0
7/26	1	107	0	9	0	0	2	0	0	0	0	0
7/27	4	94	0	7	0	1	0	0	0	0	0	0
7/28	2	142	0	1	0	0	7	0	0	0	0	0
7/29	4	260	3	6	0	1	15	0	0	0	0	0
7/30	1	250	1	12	0	0	17	0	0	0	0	0
7/31	0	158	0	2	0	0	7	0	0	0	0	0
8/01	0	131	0	3	0	0	8	0	0	0	0	0
8/02	2	139	0	4	0	1	9	0	0	0	0	0
8/03	1	190	0	3	0	1	18	0	0	0	0	0
8/04	0	168	1	1	1	0	14	0	0	1	0	0
8/05	0	159	3	5	2	0	20	0	0	0	0	0
8/06	1	208	0	7	0	0	18	0	0	0	0	0
8/07	0	153	0	1	4	0	10	0	0	0	0	0
8/08	0	92	1	6	0	0	7	0	0	0	0	0
8/09	0	107	0	5	3	0	6	0	1	0	0	0
8/10	0	118	0	3	4	0	7	0	0	0	1	0
8/11	0	99	0	3	4	0	10	0	0	0	0	0
8/12	1	73	1	3	16	0	6	1	0	1	0	0
8/13	3	78	1	0	19	0	7	0	0	2	1	0
8/14	1	61	1	1	20	0	8	0	1	4	0	0
8/15	1	38	0	0	2	0	1	0	0	0	0	0
8/16	0	53	0	1	25	0	4	0	0	4	0	0
8/17	0	55	0	2	26	0	3	0	0	4	0	0
8/18	0	31	0	3	55	0	4	0	0	12	0	0
8/19	0	29	0	0	66	0	2	0	0	8	0	0
8/20	0	27	1	0	70	0	1	0	0	8	1	0
8/21	1	16	0	1	89	0	5	0	0	5	0	0
8/22	0	9	0	0	42	0	2	0	0	5	0	0
8/23	0	17	0	0	59	0	1	0	0	5	0	0
8/24	0	11	0	0	52	0	0	0	0	3	0	0
8/25	0	13	1	1	380	0	2	0	0	51	1	0
8/26	0	7	0	0	139	0	0	0	0	23	0	0
8/27	0	6	0	0	79	0	0	0	0	11	1	0
8/28	0	2	0	0	0	0	0	0	0	0	0	0

Gill net marked

36

APPENDIX 4.-Daily counts and cumulative proportion of run for chinook, chum, pink, coho, and sockeye salmon in the Tuluksak River, Alaska, 1991.

Date	Chinook salmon		Chum salmon		Pink salmon		Coho salmon		Sockeye salmon	
	N	Cumulative Proportion	N	Cumulative Proportion	N	Cumulative Proportion	N	Cumulative Proportion	N	Cumulative Proportion
06/10	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/11	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/12	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/13	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/14	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/15	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/16	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/17	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/18	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
06/19	0	0.0000	1	0.0001	0	0.0000	0	0.0000	0	0.0000
06/20	0	0.0000	0	0.0001	0	0.0000	0	0.0000	0	0.0000
06/21	0	0.0000	0	0.0001	0	0.0000	0	0.0000	0	0.0000
06/22	0	0.0000	0	0.0001	0	0.0000	0	0.0000	0	0.0000
06/23	1	0.0014	1	0.0003	0	0.0000	0	0.0000	0	0.0000
06/24	3	0.0057	0	0.0003	0	0.0000	0	0.0000	0	0.0000
06/25	0	0.0057	0	0.0003	0	0.0000	0	0.0000	0	0.0000
06/26	3	0.0100	3	0.0007	0	0.0000	0	0.0000	0	0.0000
06/27	3	0.0143	6	0.0014	0	0.0000	0	0.0000	0	0.0000
06/28	4	0.0201	2	0.0017	0	0.0000	0	0.0000	0	0.0000
06/29	1	0.0215	11	0.0031	0	0.0000	0	0.0000	0	0.0000
06/30	6	0.0301	20	0.0057	0	0.0000	0	0.0000	0	0.0000
07/01	8	0.0416	23	0.0087	0	0.0000	0	0.0000	0	0.0000
07/02	6	0.0502	50	0.0152	0	0.0000	0	0.0000	0	0.0000
07/03	6	0.0588	64	0.0236	0	0.0000	0	0.0000	0	0.0000
07/04	28	0.0990	113	0.0383	0	0.0000	0	0.0000	0	0.0000
07/05	13	0.1176	97	0.0509	0	0.0000	0	0.0000	0	0.0000
07/06	24	0.1521	59	0.0586	1	0.0026	0	0.0000	0	0.0000
07/07	15	0.1736	115	0.0736	0	0.0026	0	0.0000	0	0.0000
07/08	23	0.2066	279	0.1100	0	0.0026	0	0.0000	0	0.0000
07/09	37	0.2597	161	0.1309	1	0.0051	0	0.0000	0	0.0000
07/10	254	0.6241	326	0.1734	3	0.0128	0	0.0000	0	0.0000
07/11	8	0.6356	296	0.2120	1	0.0153	0	0.0000	1	0.0294
07/12	38	0.6901	276	0.2479	5	0.0281	0	0.0000	2	0.0882
07/13	12	0.7073	169	0.2700	1	0.0306	0	0.0000	0	0.0882
07/14	4	0.7131	120	0.2856	2	0.0357	0	0.0000	0	0.0882
07/15	5	0.7202	169	0.3076	2	0.0408	0	0.0000	0	0.0882

APPENDIX 4.-(Continued).

Date	Chinook salmon		Chum salmon		Pink salmon		Coho salmon		Sockeye salmon	
	N	Cumulative Proportion	N	Cumulative Proportion	N	Cumulative Proportion	N	Cumulative Proportion	N	Cumulative Proportion
07/16	11	0.7360	210	0.3350	2	0.0459	0	0.0000	0	0.0882
07/17	32	0.7819	158	0.3556	5	0.0587	0	0.0000	1	0.1176
07/18	43	0.8436	390	0.4064	54	0.1964	0	0.0000	5	0.2647
07/19	27	0.8824	298	0.4452	65	0.3622	0	0.0000	1	0.2941
07/20	15	0.9039	234	0.4757	59	0.5128	0	0.0000	3	0.3824
07/21	14	0.9240	219	0.5042	28	0.5842	0	0.0000	2	0.4412
07/22	10	0.9383	232	0.5345	39	0.6837	0	0.0000	1	0.4706
07/23	3	0.9426	154	0.5545	11	0.7117	0	0.0000	0	0.4706
07/24	12	0.9598	124	0.5707	7	0.7296	0	0.0000	0	0.4706
07/25	5	0.9670	155	0.5909	8	0.7500	0	0.0000	2	0.5294
07/26	1	0.9684	107	0.6048	9	0.7730	0	0.0000	0	0.5294
07/27	4	0.9742	94	0.6171	7	0.7908	0	0.0000	0	0.5294
07/28	2	0.9770	142	0.6356	1	0.7934	0	0.0000	0	0.5294
07/29	4	0.9828	260	0.6694	6	0.8087	0	0.0000	3	0.6176
07/30	1	0.9842	250	0.7020	12	0.8393	0	0.0000	1	0.6471
07/31	0	0.9842	158	0.7226	2	0.8444	0	0.0000	0	0.6471
08/01	0	0.9842	131	0.7397	3	0.8520	0	0.0000	0	0.6471
08/02	2	0.9871	139	0.7578	4	0.8622	0	0.0000	0	0.6471
08/03	1	0.9885	190	0.7825	3	0.8699	0	0.0000	0	0.6471
08/04	0	0.9885	168	0.8044	1	0.8724	1	0.0002	1	0.6765
08/05	0	0.9885	159	0.8251	5	0.8852	2	0.0006	2	0.7647
08/06	1	0.9900	208	0.8522	7	0.9031	0	0.0006	0	0.7647
08/07	0	0.9900	153	0.8722	1	0.9056	4	0.0015	0	0.7647
08/08	0	0.9900	92	0.8842	6	0.9209	0	0.0015	1	0.7941
08/09	0	0.9900	107	0.8981	5	0.9337	3	0.0022	0	0.7941
08/10	0	0.9900	118	0.9135	3	0.9413	4	0.0030	0	0.7941
08/11	0	0.9900	99	0.9264	3	0.9490	4	0.0039	0	0.7941
08/12	1	0.9914	73	0.9359	3	0.9566	16	0.0073	1	0.8235
08/13	3	0.9957	78	0.9461	0	0.9566	19	0.0114	1	0.8529
08/14	1	0.9971	61	0.9540	1	0.9592	20	0.0157	1	0.8824
08/15	1	0.9986	38	0.9590	0	0.9592	2	0.0161	0	0.8824
08/16	0	0.9986	53	0.9659	1	0.9617	25	0.0215	0	0.8824
08/17	0	0.9986	55	0.9730	2	0.9668	26	0.0271	0	0.8824
08/18	0	0.9986	31	0.9771	3	0.9745	55	0.0389	0	0.8824
08/19	0	0.9986	29	0.9808	0	0.9745	66	0.0531	0	0.8824
08/20	0	0.9986	27	0.9844	0	0.9745	70	0.0682	1	0.9118
08/21	1	1.0000	16	0.9864	1	0.9770	89	0.0873	0	0.9118
08/22	0	1.0000	9	0.9876	0	0.9770	42	0.0963	0	0.9118
08/23	0	1.0000	17	0.9898	0	0.9770	59	0.1090	0	0.9118
08/24	0	1.0000	11	0.9913	0	0.9770	52	0.1202	0	0.9118
08/25	0	1.0000	13	0.9930	1	0.9796	380	0.2019	1	0.9412
08/26	0	1.0000	7	0.9939	0	0.9796	139	0.2318	0	0.9412
08/27	0	1.0000	6	0.9947	0	0.9796	79	0.2488	0	0.9412

APPENDIX 4.-(Continued).

Date	Chinook salmon		Chum salmon		Pink salmon		Coho salmon		Sockeye salmon	
	Cumulative N	Proportion	Cumulative N	Proportion	Cumulative N	Proportion	Cumulative N	Proportion	Cumulative N	Proportion
08/28	0	1.0000	2	0.9949	0	0.9796	0	0.2488	0	0.9412
08/29	0	1.0000	7	0.9958	0	0.9796	1	0.2490	0	0.9412
08/30	0	1.0000	11	0.9973	0	0.9796	135	0.2780	0	0.9412
08/31	0	1.0000	6	0.9980	0	0.9796	150	0.3103	0	0.9412
09/01	0	1.0000	0	0.9980	2	0.9847	149	0.3423	0	0.9412
09/02	0	1.0000	6	0.9988	0	0.9847	165	0.3778	0	0.9412
09/03	0	1.0000	1	0.9990	0	0.9847	193	0.4193	0	0.9412
09/04	0	1.0000	4	0.9995	0	0.9847	356	0.4958	0	0.9412
09/05	0	1.0000	2	0.9997	0	0.9847	389	0.5794	0	0.9412
09/06	0	1.0000	1	0.9999	0	0.9847	898	0.7725	0	0.9412
09/07	0	1.0000	0	0.9999	0	0.9847	312	0.8396	0	0.9412
09/08	0	1.0000	0	0.9999	0	0.9847	180	0.8783	0	0.9412
09/09	0	1.0000	0	0.9999	0	0.9847	157	0.9121	0	0.9412
09/10	0	1.0000	0	0.9999	3	0.9923	98	0.9331	1	0.9706
09/11	0	1.0000	0	0.9999	0	0.9923	40	0.9417	0	0.9706
09/12	0	1.0000	0	0.9999	1	0.9949	59	0.9544	0	0.9706
09/13	0	1.0000	1	1.0000	1	0.9974	45	0.9641	0	0.9706
09/14	0	1.0000	0	1.0000	0	0.9974	35	0.9716	0	0.9706
09/15	0	1.0000	0	1.0000	0	0.9974	20	0.9759	0	0.9706
09/16	0	1.0000	0	1.0000	0	0.9974	29	0.9822	1	1.0000
09/17	0	1.0000	0	1.0000	0	0.9974	59	0.9948	0	1.0000
09/18	0	1.0000	0	1.0000	1	1.0000	24	1.0000	0	1.0000
09/19	0	1.0000	0	1.0000	0	1.0000	0	1.0000	0	1.0000
Total	697		7,675		392		4,651		34	

APPENDIX 5.-Fish carcasses counted on the upstream side of the Tuluksak River weir, Alaska, 1991.

Date	Chinook salmon	Chum salmon	Sockeye salmon	Coho salmon	Pink salmon	Whitefish	Arctic grayling	Dolly Varden	Northern pike
<u>July</u>									
05	0	0	0	0	0	0	0	0	1
06	0	0	0	0	0	0	0	0	0
07	0	0	0	0	0	0	0	0	0
08	1	0	0	0	0	0	0	0	0
09	0	0	0	0	0	0	0	0	0
10	0	2	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	8	0	0	0	0	0	0	0
13	0	5	0	0	0	0	0	0	0
14	0	10	0	0	0	0	0	0	0
15	0	9	0	0	0	0	0	0	0
16	1	15	0	0	0	0	0	0	0
17	1	30	0	0	0	0	0	0	0
18	0	50	0	0	0	0	0	0	0
19	0	46	0	0	0	1	0	0	0
20	0	49	0	0	0	0	0	0	0
21	0	48	0	0	0	0	0	0	0
22	1	57	0	0	0	0	0	0	0
23	0	53	0	0	0	0	0	0	0
24	0	73	0	0	0	0	0	0	0
25	0	81	0	0	2	0	0	0	0
26	1	93	0	0	4	0	0	0	0
27	2	102	0	0	6	0	0	0	0
28	4	156	0	0	10	0	0	0	0
29	7	203	0	0	34	0	0	0	0
30	15	215	0	0	42	0	0	0	0
31	7	152	0	0	73	0	0	0	0
<u>August</u>									
01	25	183	0	0	61	0	0	0	0
02	13	151	0	0	60	0	0	0	0
03	11	157	0	0	56	0	0	0	0
04	13	128	0	0	31	0	0	0	0
05	21	239	0	0	70	0	0	0	0
06	9	173	0	0	52	0	0	0	0
07	9	172	0	0	35	0	0	0	0
08	10	163	0	0	16	0	0	0	0
09	6	223	1	0	28	0	0	0	0
10	3	232	0	0	27	0	0	0	0
11	1	166	0	0	14	0	0	0	0
12	2	105	0	0	17	0	0	0	0

APPENDIX 5.-(Continued).

Date	Chinook salmon	Chum salmon	Sockeye salmon	Coho salmon	Pink salmon	Whitefish	Arctic grayling	Dolly Varden	Northern pike
13	1	109	0	0	16	0	0	0	0
14	0	87	2	0	8	0	0	0	0
15	1	51	0	0	5	0	0	0	0
16	1	66	2	0	8	0	0	0	0
17	0	65	1	0	9	0	0	0	0
18	0	52	1	0	4	0	0	0	0
19	0	47	2	0	5	0	0	0	0
20	0	40	1	0	2	0	0	0	0
21	0	37	0	0	4	0	0	0	0
22	0	19	0	0	1	0	0	0	0
23	0	41	0	0	4	0	0	0	0
24	0	34	1	0	7	1	0	0	0
25	0	34	2	0	7	0	0	0	0
26	0	28	0	0	1	0	0	0	0
27	1	16	0	0	2	2	0	0	0
28	0	16	0	0	2	0	0	0	0
29	0	7	0	0	0	1	0	0	1
30	0	7	2	0	0	2	0	0	2
31	0	12	0	0	0	3	0	0	0
<u>September</u>									
01	0	15	0	0	4	3	0	0	0
02	0	8	0	0	0	0	0	0	0
03	0	11	0	2	0	2	0	0	0
04	0	2	0	0	0	5	0	0	0
05	0	1	1	0	0	2	0	0	0
06	0	5	0	0	0	2	0	0	1
07	0	4	0	0	0	1	0	0	0
08	0	1	0	0	0	3	0	0	0
09	0	7	0	0	1	2	0	0	0
10	0	3	0	0	0	5	0	0	0
11	0	0	0	1	0	3	0	1	0
12	0	1	0	1	1	3	0	0	2
13	0	0	0	1	0	3	0	0	1
14	0	0	0	0	0	1	0	0	1
15	0	0	1	2	0	5	0	0	0
16	0	0	0	2	0	1	1	0	0
17	0	1	0	2	0	2	0	0	1
18	0	0	0	2	0	4	0	0	0
Total	167	4,376	17	13	730	57	1	1	10

Appendix 6.-Estimated age and sex composition of weekly chum salmon passage from the Tuluksak River, Alaska, 1991, and test for age composition difference between sexes.

		Brood Year and Age Group				TOTAL
		1988	1987	1986	1985	
		0.2	0.3	0.4	0.5	
Stratum Dates: WEEKS 25 - 26						
Sampling Dates: 6/16 - 29						
Sample Size: 23						
Female	Percent of Sample	0.0	17.4	26.1	0.0	43.5
	Number in Passage	0	4	6	0	10
Male	Percent of Sample	0.0	0.0	56.5	0.0	56.5
	Number in Passage	0	0	14	0	14
Total	Percent of Sample	0.0	17.4	82.6	0.0	100.0
	Number in Passage	0	4	20	0	24
	Standard Error	0	2	2	0	
Stratum Dates: WEEK 27						
Sampling Dates: 6/30 - 7/6						
Sample Size: 137						
Female	Percent of Sample	0.0	4.4	22.6	0.0	27.0
	Number in Passage	0	19	96	0	115
Male	Percent of Sample	0.0	10.2	59.9	2.9	73.0
	Number in Passage	0	44	255	12	311
Total	Percent of Passage	0.0	14.6	82.5	2.9	100.0
	Number in Catch	0	62	351	12	426
	Standard Error	0	13	14	6	
Stratum Dates: WEEK 28						
Sampling Dates: 7/7 - 13						
Sample Size: 141						
Female	Percent of Sample	0.7	15.6	14.9	0.7	31.9
	Number in Passage	12	253	242	12	518
Male	Percent of Sample	0.0	24.1	43.3	0.7	68.1
	Number in Passage	0	391	702	12	1,104
Total	Percent of Sample	0.7	39.7	58.2	1.4	100.0
	Number in Passage	12	644	943	23	1,622
	Standard Error	12	67	68	16	
Stratum Dates: WEEK 29						
Sampling Dates: 7/14 - 20						
Sample Size: 135						
Female	Percent of Sample	3.7	25.9	21.5	0.0	51.1
	Number in Passage	58	409	339	0	807
Male	Percent of Sample	0.7	26.7	20.7	0.7	48.9
	Number in Passage	12	421	327	12	772
Total	Percent of Sample	4.4	52.6	42.2	0.7	100.0
	Number in Passage	70	831	667	12	1,579
	Standard Error	28	68	67	12	

Appendix 6.-(Continued)

		Brood Year and Age Group				TOTAL
		1988	1987	1986	1985	
		0.2	0.3	0.4	0.5	
Stratum Dates: WEEK 30						
Sampling Dates: 7/21 - 27						
Sample Size: 141						
Female	Percent of Sample	1.4	29.1	13.5	0.0	44.0
	Number in Passage	15	316	146	0	477
Male	Percent of Sample	2.1	39.7	14.2	0.0	56.0
	Number in Passage	23	431	154	0	608
Total	Percent of Sample	3.6	68.8	27.7	0.0	100.0
	Number in Passage	39	746	300	0	1,085
	Standard Error	17	42	41	0	
Stratum Dates: WEEK 31						
Sampling Dates: 7/28 - 8/3						
Sample Size: 148						
Female	Percent of Sample	2.0	32.4	11.5	0.0	46.0
	Number in Passage	26	412	146	0	584
Male	Percent of Sample	0.0	36.5	17.6	0.0	54.1
	Number in Passage	0	463	223	0	687
Total	Percent of Sample	2.0	68.9	29.1	0.0	100.0
	Number in Passage	26	875	369	0	1,270
	Standard Error	0	0	0	0	
Stratum Dates: WEEK 32						
Sampling Dates: 8/4 - 10						
Sample Size: 151						
Female	Percent of Sample	5.3	50.3	8.0	0.0	63.6
	Number in Passage	53	506	80	0	639
Male	Percent of Sample	0.7	29.8	6.0	0.0	36.4
	Number in Passage	7	299	60	0	366
Total	Percent of Sample	6.0	80.1	13.9	0.0	100.0
	Number in Passage	60	805	140	0	1,005
	Standard Error	0	0	0	0	
Stratum Dates: WEEK 33						
Sampling Dates: 8/11 - 17						
Sample Size: 154						
Female	Percent of Sample	5.2	58.4	12.3	0.0	76.0
	Number in Passage	24	267	56	0	347
Male	Percent of Sample	0.7	16.2	7.1	0.0	24.0
	Number in Passage	3	74	33	0	110
Total	Percent of Sample	5.8	74.7	19.5	0.0	100.0
	Number in Passage	27	341	89	0	457
	Standard Error	0	0	0	0	

Appendix 6.-(Continued)

		Brood Year and Age Group				TOTAL
		1988	1987	1986	1985	
		0.2	0.3	0.4	0.5	
Stratum Dates: WEEK 34 - 37						
Sampling Dates: 8/18 - 9/14						
Sample Size: 81						
Female	Percent of Sample	3.7	55.6	11.1	0.0	70.4
	Number in Passage	8	115	23	0	146
Male	Percent of Sample	0.0	21.0	8.6	0.0	29.6
	Number in Passage	0	43	18	0	61
Total	Percent of Sample	3.7	76.6	19.8	0.0	100.0
	Number in Passage	8	158	41	0	207
	Standard Error	4	10	9	0	
Stratum Dates: SEASON						
Sampling Dates: 6/16 - 8/24						
Sample Size: 1,111						
Female	Percent of Sample	2.6	30.0	14.8	0.2	47.5
	Number in Passage	196	2,301	1,135	12	3,643
Male	Percent of Sample	0.6	28.2	23.3	0.5	52.5
	Number in Passage	44	2,167	1,785	36	4,032
Total	Percent of Sample	3.1	58.2	38.0	0.6	100.0
	Number in Passage	240	4,468	2,920	47	7,675
	Standard Error	35	106	105	21	

Test for age composition difference between sexes in the escapement.

Proportion of males	<i>a</i>	0.054	0.632	0.312	0.003	100%
V(Proportion males)	<i>b</i>	7.11E-01	8.29E+00	4.47E+00	5.89E-02	
Proportion of females	<i>a</i>	0.011	0.537	0.443	0.009	100%
V(Proportion females)	<i>b</i>	1.33E-01	6.51E+00	5.14E+00	1.12E-01	
Z-test statistic		0.047	0.024	-0.042	-0.014	
P	<i>c</i>	0.232	0.240	0.233	0.245	

a Proportion within each sex by age.

b V= variance for proportions

c P value. Z was significant at alpha =0.05 if P was less than Bonferroni adjustment level of 0.01

Appendix 7. - Estimated age and sex composition of weekly chinook salmon passage from the Tuluksak River, Alaska, 1991, and test for age composition difference between sexes in the escapement.

Brood Year and Age Group															
		1988										1983		TOTAL	
		1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5				
Stratum Dates: WEEKS 26 - 27															
Sampling Dates: 6/23 - 7/6															
Sample Size: 91															
Female	Percent of Sample	0.0	3.3	4.4	1.1	13.2	2.2	1.1	2.2	0.0	2.2	29.7			
	Number in Passage	0	3	5	1	14	2	1	2	0	2	31			
Male	Percent of Sample	1.1	13.2	23.1	14.3	9.9	5.5	1.1	1.1	0.0	1.1	70.3			
	Number in Passage	1	14	24	15	10	6	1	1	0	1	75			
Total	Percent of Sample	1.1	16.5	27.5	15.4	23.1	7.7	2.2	3.3	0.0	3.3	100.0			
	Number in Passage	1	17	29	16	24	8	2	3	0	3	106			
	Standard Error	1	4	5	4	5	3	2	2	0	2				
Stratum Dates: WEEK 28															
Sampling Dates: 7/7 - 7/13															
Sample Size: 72															
Female	Percent of Sample	0.0	0.0	1.4	0.0	12.5	0.0	4.2	0.0	0.0	0.0	18.1			
	Number in Passage	0	0	5	0	48	0	16	0	0	0	70			
Male	Percent of Sample	0.0	16.7	20.8	12.5	18.1	6.9	2.8	2.8	0.0	1.4	82.0			
	Number in Passage	0	65	81	48	70	27	11	11	0	5	317			
Total	Percent of Sample	0.0	16.7	22.2	12.5	30.6	6.9	7.0	2.8	0.0	1.4	100.0			
	Number in Passage	0	65	86	48	118	27	27	11	0	5	387			
	Standard Error	0	17	19	15	21	12	12	8	0	5				
Stratum Dates: WEEKS 29															
Sampling Dates: 7/14 - 7/20															
Sample Size: 129															
Female	Percent of Sample	0.0	0.0	3.1	0.0	26.4	0.8	9.3	1.6	0.0	0.8	41.9			
	Number in Passage	0	0	4	0	36	1	13	2	0	1	57			
Male	Percent of Sample	0.0	18.6	7.8	10.9	13.2	4.7	2.3	0.8	0.0	0.0	58.1			
	Number in Passage	0	25	11	15	18	6	3	1	0	0	80			
Total	Percent of Sample	0.0	18.6	10.9	10.9	39.5	5.4	11.6	2.3	0.0	0.8	100.0			
	Number in Passage	0	25	15	15	54	7	16	3	0	1	137			
	Standard Error	0	5	4	4	6	3	4	2	0	1				
Stratum Dates: WEEKS 30 - 34															
Sampling Dates: 7/21 - 8/24															
Sample Size: 56															
Female	Percent of Sample	0.0	0.0	3.6	0.0	37.5	1.8	12.5	3.6	3.6	0.0	62.5			
	Number in Passage	0	0	2	0	25	1	8	2	2	0	42			
Male	Percent of Sample	0.0	5.4	10.7	1.8	14.3	0.0	3.6	1.8	0.0	0.0	37.5			
	Number in Passage	0	4	7	1	10	0	2	1	0	0	25			
Total	Percent of Sample	0.0	5.4	14.3	1.8	51.8	1.8	16.1	5.4	3.6	0.0	100.0			
	Number in Passage	0	4	10	1	35	1	11	4	2	0	67			
	Standard Error	0	2	3	1	5	1	3	2	2	0				

Appendix 7 (continued)

		Brood Year and Age Group																			
		1988			1987			1986			1985			1984			1983				
		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	
Stratum Dates:																					
Sampling Dates:																					
Sample Size:																					
SEASON																					
6/23 - 8/24																					
Sample Size:																					
348																					
Female	Percent of Sample	0.0	0.5	2.4	0.2	17.7	0.7	5.5	1.0	0.3	0.5	28.8									
	Number in Passage	0	3	17	1	124	5	38	7	2	3	201									
Male	Percent of Sample	0.2	15.4	17.6	11.4	15.5	5.6	2.5	2.0	0.0	0.9	71.2									
	Number in Passage	1	108	123	80	108	39	18	14	0	7	495									
Total	Percent of Sample	0.2	15.9	20.0	11.6	33.2	6.3	8.0	3.0	0.3	1.4	100.0									
	Number in Passage	1	111	140	81	232	44	56	21	2	10	697									
Standard Error		1	18	20	16	23	12	13	8	2	6										

Test for age composition difference between sexes in the escapement.

Proportion of males	a	0.000	0.017	0.083	0.006	0.616	0.023	0.192	0.034	0.012	0.017	100%
Variance for females	b	0.00E+00	1.02E-04	1.07E-03	3.41E-05	1.09E-02	1.24E-04	2.95E-03	1.81E-04	4.87E-05	3.10E-05	100%
Proportion of females	a	0.002	0.217	0.247	0.160	0.218	0.079	0.035	0.029	0.000	0.013	
Variance for males	b	2.30E-04	3.68E-03	4.02E-04	3.21E-03	3.74E-03	2.38E-03	1.51E-03	1.52E-03	0.00E+00	1.06E-03	
Z-test statistic		-0.155	-3.250	-2.303	-2.712	3.295	-1.114	2.340	0.134	1.708	0.114	
P	c	0.877	0.001	0.021	0.007	0.001	0.265	0.019	0.893	0.088	0.909	

a Proportion within each sex by age.

b V= variance for proportions of each age within each sex.

c P value. Z was significant at alpha =0.05 if P was less than Bonferroni adjustment level of 0.005.

Appendix 8.-Estimated age and sex composition of weekly sockeye salmon passage from the Tuluksak River, Alaska 1991.

		Brood Year and Age Group							
		1988	1987		1986		1985		
		0.2	0.3	1.2	1.3	2.2	1.4	2.3	TOTAL
Stratum Dates:	SEASON								
Sampling Dates:	7/14 - 9/21								
Sample Size:	24								
Female	Percent of Sample	0.0	0.0	8.3	8.3	4.2	4.2	8.3	33.3
	Number in Passage	0	0	3	3	1	1	3	11
Male	Percent of Sample	0.0	0.0	20.8	25.0	12.5	0.0	8.3	66.7
	Number in Passage	0	0	7	9	4	0	3	23
Total	Percent of Sample	0.0	0.0	29.2	33.3	16.7	4.2	16.7	100.0
	Number in Passage	0	0	10	11	6	1	6	34
	Standard Error	0	0	3	3	3	1	3	

Appendix 9.-Estimated age and sex composition of weekly coho salmon passage from the Tuluksak River, Alaska, 1991, and test for age composition difference between sexes.

		Brood Year and Age Group				
		1988	1987	1986		
		1.1	2.1	2.2	3.1	TOTAL
<hr/>						
Stratum Dates: WEEKS 32 - 33						
Sampling Dates: 8/4- 17						
Sample Size: 120						
Female	Percent of Sample	0.0	40.0	0.0	4.2	44.2
	Number in Passage	0	50	0	5	56
Male	Percent of Sample	2.5	50.0	2.5	0.8	55.8
	Number in Passage	3	63	3	1	70
Total	Percent of Sample	2.5	90.0	2.5	5.0	100.0
	Number in Passage	3	113	3	6	126
	Standard Error	2	3	2	3	
<hr/>						
Stratum Dates: WEEK 34						
Sampling Dates: 8/18 - 24						
Sample Size: 106						
Female	Percent of Sample	0.0	34.9	0.0	1.9	36.8
	Number in Passage	0	151	0	8	159
Male	Percent of Sample	0.0	59.4	0.9	2.8	63.2
	Number in Passage	0	257	4	12	274
Total	Percent of Sample	0.0	94.3	0.9	4.7	100.0
	Number in Passage	0	408	4	20	433
	Standard Error	0	10	4	9	
<hr/>						
Stratum Dates: WEEK 35						
Sampling Dates: 8/25 - 31						
Sample Size: 106						
Female	Percent of Sample	1.9	44.3	0.9	3.8	50.9
	Number in Passage	17	392	8	33	450
Male	Percent of Sample	0.0	41.5	0.9	6.6	49.0
	Number in Catch	0	367	8	58	434
Total	Percent of Sample	1.9	85.9	1.9	10.4	100.0
	Number in Passage	17	759	17	92	884
	Standard Error	12	30	12	26	
<hr/>						
Stratum Dates: WEEK 36						
Sampling Dates: 9/1 - 7						
Sample Size: 103						
Female	Percent of Sample	0.0	42.7	1.0	9.7	53.4
	Number in Passage	0	1,052	24	239	1,315
Male	Percent of Sample	0.0	35.9	2.9	7.8	46.6
	Number in Passage	0	884	72	191	1,147
Total	Percent of Sample	0.0	78.6	3.9	17.5	100.0
	Number in Passage	167	1,936	96	430	2,462
	Standard Error	0	100	47	93	

Appendix 9.-(continued).

		Brood Year and Age Group				
		1988	1987	1986		
		1.1	2.1	2.2	3.1	TOTAL
Stratum Dates:		WEEK 37				
Sampling Dates:		9/8 - 14				
Sample Size:		105				
Female	Percent of Sample	0.0	47.6	4.8	9.5	61.9
	Number in Passage	0	292	29	58	380
Male	Percent of Sample	0.0	29.5	1.9	6.7	38.1
	Number in Passage	0	181	12	41	234
Total	Percent of Sample	0.0	77.1	6.7	16.2	100.0
	Number in Passage	167	474	41	99	614
	Standard Error	0	25	15	22	
Stratum Dates:		WEEK 38				
Sampling Dates:		9/5 - 18				
Sample Size:		107				
Female	Percent of Sample	0.0	49.5	1.9	12.2	63.6
	Number in Passage	0	65	2	16	84
Male	Percent of Sample	1.9	25.2	0.9	8.4	36.4
	Number in Passage	2	33	1	11	48
Total	Percent of Sample	1.9	74.8	2.8	20.6	100.0
	Number in Passage	167	99	4	27	132
	Standard Error	2	6	2	5	
Stratum Dates:		SEASON				
Sampling Dates:		8/4- 9/18				
Sample Size:		647				
Female	Percent of Sample	0.4	43.1	1.4	7.7	52.5
	Number in Passage	17	2,003	64	360	2,444
Male	Percent of Sample	0.1	38.4	2.2	6.8	47.4
	Number in Passage	6	1,786	100	315	2207
Total	Percent of Sample	0.5	81.5	3.5	14.5	100.0
	Number in Passage	167	3,789	164	675	4,651
	Standard Error	15	174	82	158	

Z-test of age composition difference between sexes.

Proportion of males	a	0.007	0.820	0.026	0.147	1.000	100%
V(Proportion of males)	b	2.32E-05	5.00E-03	1.37E-04	1.04E-03	6.02E-03	
Proportion of females	a	0.003	0.809	0.045	0.143	1.000	100%
V(Proportion of females)	b	1.31E-06	5.86E-03	3.85E-04	1.10E-03	7.39E-03	
Z-test statistic		0.866	0.098	-0.840	0.101	0.000	
P	c	0.037	0.212	0.040	0.211	0.250	

a Proportion within each sex by age.

b V= variance for proportions.

c P value. Z was significant at alpha =0.05 if P was less than Bonferroni adjustment level of 0.0125.